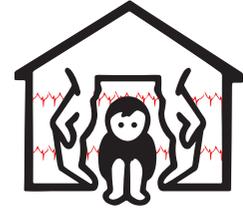


Journal of Pediatric Emergency and Intensive Care Medicine

Çocuk Acil ve Yoğun Bakım Dergisi



TURKISH SOCIETY OF
PEDIATRIC EMERGENCY AND
INTENSIVE CARE MEDICINE

Volume / Cilt: 13

Issue / Sayı: 1

Year / Yıl: 2026

E-ISSN: 2148-7332

Research Articles / Özgün Araştırmalar

- Salbutamol Plus Mask Oxygen Versus HFNC in Bronchiolitis**
Bronşiolitte Salbutamol Plus Maske Oksijen ve HFNC Karşılaştırması
Şule Zuhal Gürsoy Durak, Özlem Tolu Kendir, Nilgün Erkek, Ömerhan Başpınar, Ramazan Gürlü; Antalya, Türkiye
- Quantitative Measurement of Lung Radiodensity on Chest X-ray Improves Diagnosis of Foreign Body Aspirations in Children**
Direkt Akciğer Grafisinde Akciğer Radyodansitesinin Kantitatif Ölçümü Çocuklarda Yabancı Cisim Aspirasyonlarının Tanısını İyileştirir
Ayten Bilen, Fatma Ceren Sarıoğlu, Efil Aydın, Serra Sabuncu, Osman Zeki Karakuş, Oktay Ulusoy, Handan Güleriyüz, Oğuz Ateş, Gülce Hakgüder, Mustafa Olguner, Miraç Feza Akgür; İzmir, Türkiye
- Risk Factors in Cardiovascular Surgery in Down Syndrome Patients: Single-center Experience**
Down Sendromlu Hastalarda Kardiyovasküler Cerrahide Risk Faktörleri: Tek Merkez Deneyimi
Sinan Yavuz, Umut Berk Mercan, Selman Kesici, Ahmet Aydın, Hayrettin Hakan Aykan, Mustafa Yılmaz, Benan Bayrakçı; Ankara, Türkiye
- Short First-aid Training Improves Parental Knowledge of Pediatric Head Trauma: A Pilot Study**
Kısa İlk Yardım Eğitimi Ebeveynlerin Pediyatrik Kafa Travması Bilgisini Artırıyor: Pilot Çalışma
Semra Söngüt, Hacer Delibaş, Zehra Ünal; Çorum, Türkiye
- Clinico-etiological Profile of Poisoning in Children and Impact of Counselling on Child Care and Safety Practices A Prospective Study from North India**
Çocuklarda Zehirlenmelerin Klinik-etiyolojik Profili ve Danışmanlığın Çocuk Bakımı ile Güvenlik Uygulamaları Üzerindeki Etkisi Kuzey Hindistan'dan İleriye Yönelik Bir Çalışma
Shikhar Gupta, Urmila Jhamb, Deepak Kumar, Pallavi Pallavi; New Delhi, Ghaziabad, India
- Pediatric Acute Liver Failure: Etiologies, Intensive Care Management, and Prognostic Trends in a Tertiary Center**
Üçüncü Basamak Bir Merkezde Pediyatrik Akut Karaciğer Yetmezliği: Etiyoloji, Yoğun Bakım Yaklaşımı ve Prognoz
Fulden Aycan, Tanil Kendirli, Emrah Gün, Edin Botan, Zariife Kuloğlu, Ceyda Tuna Kırsaçloğlu, Meltem Koloğlu, Beyza Doğanay Erdoğan, Suat Fitöz, Erdal İnce, Deniz Balcı, Aydan Kansu; Ankara, Türkiye

Case Reports / Olgu Sunumları

- Energy Drink Associated Severe Myocardial Injury in a Child: A Case Report**
Çocukta Enerji İçeceği ile İlişkili Şiddetli Miyokardiyal Hasar: Olgu Sunumu
Bayram Bayramov, Merve Havan, Eda Eydurhan, Ayşen Durak Aslan, Mehmet Gökhan Ramoğlu, Tanil Kendirli; Ankara, Türkiye
- Hernia Inguinalis Ovarii: A Case of Groin Mass Needing Urgent Attention**
Hernia Inguinalis Ovarii: Acil Müdahale Gerektiren Kasık Kütlesi Olgusu
Rashika Mony, Prema Choudhary; Chhattisgarh, India
- Can Social Media Challenges Determine Life or Death? Two Adolescent Cases from the Pediatric Intensive Care Unit**
Sosyal Medya Meydan Okumaları Yaşamı mı Ölümü mü Belirliyor? Yoğun Bakımda İzlenen İki Ergen Olgu
Kyimet Ezgi Aydın, Fatih Battal; Çanakkale, Türkiye
- When the Pressure Is Not High: A Case of PRES in a Normotensive Child**
Basınc Yüksek Değilken: Normotansif Bir Çocukta PRES Olgusu
Azie Jumaatul Adawiyah Binti Nabir, Assyifa Binti Nik Mazian, Aliyyah Mohammad Khuzaini; Nilai, Ampang, Malaysia

Review / Derleme

- Non-invasive Mechanical Ventilation in Children and Newborns: A Bibliometric Analysis Study and Literature Review**
Çocuklarda ve Yenidoğanlarda Non-invaziv Mekanik Ventilasyon: Bibliyometrik Analiz Çalışması ve Literatür Taraması
Sri Martuti, Annang Giri Moelyo, Hanum Ferdian, Sari Dwi Jayanti; Surakarta, Indonesia

1



TURKISH SOCIETY OF
PEDIATRIC EMERGENCY AND
INTENSIVE CARE MEDICINE

Journal of Pediatric Emergency and Intensive Care Medicine

Çocuk Acil ve Yoğun Bakım Dergisi

EDITORIAL BOARD / EDITÖRLER KURULU

Honorary Editor

Prof. Metin Karaböcüoğlu, MD.

Rectorship of Biruni University, Protokol Yolu No:45, 10. Yıl Cd., 34010 Zeytinburnu, İstanbul, Türkiye

E-mail: mkara63@hotmail.com

ORCID: <https://orcid.org/0000-0003-2854-0562>

Editor in Chief

Prof. Hayri Levent Yılmaz, MD.

Çukurova University Faculty of Medicine, Department of Child Health and Diseases, Division of Pediatric Emergency Medicine, Adana, Türkiye

E-mail: hlevent01@gmail.com

ORCID: <https://orcid.org/0000-0003-0873-9814>

Pediatric Emergency Editors

Prof. Murat Duman, MD.

Dokuz Eylül University Faculty of Medicine, Department of Child Health and Diseases, Division of Pediatric Emergency Medicine, İzmir, Türkiye

E-mail: mduman@deu.edu.tr

ORCID: <https://orcid.org/0000-0001-6767-5748>

Assoc. Prof. Emel Ulusoy

Dokuz Eylül University Faculty of Medicine, Department of Child Health and Diseases, Division of Pediatric Emergency Medicine, İzmir, Türkiye

E-mail: ulusoy_emel@hotmail.com

ORCID: <https://orcid.org/0000-0002-2827-1553>

Prof. Halim Hennes, MD.

Texas Southwestern University Faculty of Medicine, Department of Pediatric Emergency Medicine, Dallas, USA

E-mail: halim.hennes@utsouthwestern.edu

ORCID: <https://orcid.org/0000-0002-1230-7371>

Pediatric Intensive Care Editors

Prof. Agop Çıtak, MD.

Acıbadem University Faculty of Medicine, Department of Pediatrics, Division of Pediatric Intensive Care Medicine, İstanbul, Türkiye

E-mail: agopcitak@hotmail.com

ORCID: <https://orcid.org/0000-0002-5108-3913>

Prof. Dinçer Yıldızdaş, MD.

Çukurova University Faculty of Medicine, Department of Pediatrics, Division of Pediatric Intensive Care Medicine, Adana, Türkiye

E-mail: dyildzdas@gmail.com

ORCID: <https://orcid.org/0000-0003-0739-5108>

Journal of Pediatric Emergency and Intensive Care Medicine

Çocuk Acil ve Yoğun Bakım Dergisi



TURKISH SOCIETY OF
PEDIATRIC EMERGENCY AND
INTENSIVE CARE MEDICINE

EDITORIAL BOARD / EDITÖRLER KURULU

Pediatric Emergency Associate Editors

Assoc. Prof. Esen Besli

Istanbul Medeniyet University Faculty of Medicine, Department of Pediatric Emergency Medicine, Istanbul, Türkiye

E-mail: besliesen@gmail.com

ORCID: <https://orcid.org/0000-0001-6837-5384>

Assoc. Prof. Anıl Er

Dokuz Eylül University Faculty of Medicine, Department of Pediatric Health and Diseases, Division of Pediatric Emergency, İzmir, Türkiye

E-mail: anler.278@gmail.com

ORCID: <https://orcid.org/0000-0003-3452-5123>

Assoc. Prof. Ahmet Kağan Özkaya

Karadeniz Technical University Faculty of Medicine, Department of Pediatrics, Pediatric Emergency Department, Trabzon, Türkiye

E-mail: akozkaya@ktu.edu.tr

ORCID: <https://orcid.org/0000-0003-3562-6495>

Pediatric Intensive Care Associate Editors

Assoc. Prof. Selman Kesici

Hacettepe University Faculty of Medicine, Department of Health and Diseases, Division of Pediatric Intensive Care, Ankara, Türkiye

E-mail: drselmankesici@gmail.com

ORCID: <https://orcid.org/0000-0003-4746-6986>

Assoc. Prof. Ebru Atike Ongun

University of Health Sciences Türkiye, Antalya Training and Research Hospital, Clinic of Health and Diseases, Division of Pediatric Intensive Care, Antalya, Türkiye

E-mail: ebru_temel@yahoo.com

ORCID: <https://orcid.org/0000-0002-1248-8635>

Prof. Mutlu Uysal Yazıcı, MD.

Gazi University Faculty of Medicine, Department of Health and Diseases, Division of Pediatric Intensive Care, Ankara, Türkiye

E-mail: mutluuysal@yahoo.com

ORCID: <https://orcid.org/0000-0001-7377-4718>

Assoc. Prof. Nagehan Aslan

University of Health Sciences Türkiye, Başakşehir Çam and Sakura City Hospital, Clinic of Child Health and Diseases, Division of Pediatric Intensive Care, Istanbul, Türkiye

E-mail: nagehan_aslan@hotmail.com

ORCID: <https://orcid.org/0000-0002-6140-8873>

Editorial Board

Prof. Michael K. Kim, MD.

University of Wisconsin, Faculty of Medicine and Department of Public Health BerbeeWalsh Emergency Medicine, Wisconsin, USA

E-mail: mkkim@medicine.wisc.edu

Prof. Santiago Mintegi, MD.

Cruces University Hospital, Clinic of Pediatric Emergency, Bilbao, Spain

ORCID: <https://orcid.org/0000-0002-2342-8881>

Prof. Harold K. Simon, MD.

Emory University Faculty of Medicine, Department of Pediatrics Emergency Medicine, Georgia, USA

ORCID: <https://orcid.org/0000-0003-3749-4772>

Assoc. Prof. Rachel M. Stanley

The Ohio State University Nationwide Children's Hospital, Clinic of Pediatric Emergency Medicine, Ohio, USA

ORCID: <https://orcid.org/0000-0002-4938-3079>

Prof. Said Hachimi Idrissi, MD.

Ghent University Faculty of Medicine, Department of Pediatrics, Division of Pediatric Emergency Medicine, Ghent, Belgium

ORCID: <https://orcid.org/0000-0002-8455-1410>

Prof. Itai Shavit, MD.

Rambam Health Care Campus, Pediatric Emergency Medicine Unit, Haifa, Israel

ORCID: <https://orcid.org/0000-0003-4504-8019>

Assoc. Prof. Nancy S. Ghanayem

Wisconsin Children's Hospital, Clinic of Pediatric Intensive Care, Wisconsin, USA

Scopus ID: 6602122924

Prof. Zena Leah Harris, MD.

Northwestern University Feinberg Faculty of Medicine, Department of Pediatrics, Division of Pediatric Critical Care Medicine, Chicago, USA

ORCID: <https://orcid.org/0000-0003-0110-8438>

Assoc. Prof. Rambod Amirnovin

Southern California University Keck Faculty of Medicine, Department of Clinical Pediatrics, Division of Critical Care Medicine; Childrens Hospital Los Angeles, Clinic of Anesthesia, Unit of Critical Care Medicine, California, USA

Scopus ID: 57194773343

Prof. Prof. Peter Luckett, MD.

Texas Southwestern University Dallas Faculty of Medicine, Department of Pediatrics, Division of Pediatric Intensive Care Medicine, Dallas, USA

ORCID: <https://orcid.org/0000-0002-9738-6290>

Technical Publication Editor

Assoc. Prof. Emel Ulusoy

Dokuz Eylül University Faculty of Medicine, Department of Pediatric Health and Diseases, Division of Pediatric Emergency, İzmir, Türkiye

E-mail: ulusoy_emel@hotmail.com

ORCID: <https://orcid.org/0000-0002-2827-1553>



TURKISH SOCIETY OF
PEDIATRIC EMERGENCY AND
INTENSIVE CARE MEDICINE

Journal of Pediatric Emergency and Intensive Care Medicine

Çocuk Acil ve Yoğun Bakım Dergisi

EDITORIAL BOARD / EDITÖRLER KURULU

Statistics Editors

Assoc. Prof. Anıl Er

Dokuz Eylül University Faculty of Medicine, Department of Pediatric Health and Diseases, Division of Pediatric Emergency, İzmir, Türkiye

E-mail: anler.278@gmail.com

ORCID: <https://orcid.org/0000-0003-3452-5123>

Assoc. Prof. Yaşar Sertdemir

Çukurova University Faculty of Medicine, Department of Biostatistics, Adana, Türkiye

ORCID: <https://orcid.org/0000-0003-4455-3590>

Assoc. Prof. İlker Ünal

Çukurova University Faculty of Medicine, Department of Biostatistics, Adana, Türkiye

E-mail: ilkerun@cu.edu.tr

ORCID: <https://orcid.org/0000-0002-9485-3295>

Language Editors

Prof. Halim Hennes, MD.

Texas Southwestern University Faculty of Medicine, Department of Pediatric Emergency Medicine, Dallas, USA

ORCID: <https://orcid.org/0000-0002-1230-7371>

Assoc. Prof. Ebru Atike Ongun

University of Health Sciences Türkiye, Antalya Training and Research Hospital, Clinic of Pediatric Health and Diseases, Division of Pediatric Intensive Care, Antalya, Türkiye

E-mail: ebru_temel@yahoo.com

ORCID: <https://orcid.org/0000-0002-1248-8635>

Advertisement Managers

Prof. Oğuz Dursun, MD.

Akdeniz University Faculty of Medicine, Department of Pediatric Health and Diseases, Division of Pediatric Intensive Care, Antalya, Türkiye

E-mail: oguzdursun@gmail.com

ORCID: <https://orcid.org/0000-0001-5482-3780>

Assoc. Prof. Aykut Çağlar

Aydın Adnan Menderes Faculty of Medicine, Department of Pediatric Health and Diseases, Division of Pediatric Intensive Care, Aydın, Türkiye

E-mail: aykutcaglar@gmail.com

ORCID: <https://orcid.org/0000-0002-2805-5420>

Prof. Dr. Murat Duman

Dokuz Eylül University Faculty of Medicine, Department of Child Health and Diseases, Division of Pediatric Emergency Medicine, İzmir, Türkiye

Editorial Office

Address: Çukurova Üniversitesi Tıp Fakültesi, Çocuk Sağlığı ve Hastalıkları AD, Çocuk Acil BD, 01330, Sarıçam, Adana, Turkey

Phone: +90 322 338 60 60 / 3654

E-mail: dergi@caybdergi.com

The Journal of Pediatric Emergency and Intensive Care Medicine is a publication of "Society of Pediatric Emergency and Intensive Care Medicine".
Çocuk Acil ve Yoğun Bakım Dergisi, Çocuk Acil Tıp ve Yoğun Bakım Derneği'nin bilimsel yayınıdır.



Publisher Contact/Yayınevi İletişim

Address/Adres: Molla Gürani Mah. Kaçamak Sk. No: 21/1
34093 İstanbul, Türkiye

Phone/Telefon: +90 (530) 177 30 97

E-mail/E-posta: info@galenos.com.tr/yayin@galenos.com.tr

Web: www.galenos.com.tr

Publisher Certificate Number/Yayıncı Sertifika No: 14521

Publication Date/Yayın Tarihi: Nisan 2026/April 2026

ISSN: 2146-2399 E-ISSN: 2148-7332

International periodical journal published three times in a year.

Yılda üç kez yayımlanan süreli yayındır.

Journal of Pediatric Emergency and Intensive Care Medicine

Çocuk Acil ve Yoğun Bakım Dergisi



TURKISH SOCIETY OF
PEDIATRIC EMERGENCY AND
INTENSIVE CARE MEDICINE

Please refer to the journal's webpage (<https://www.caybdergi.com/>) for "Journal Policies" and "Instructions to Authors". The editorial and publication processes of the journal are shaped in accordance with the guidelines of ICMJE, COPE, WAME, CSE and EASE. The Journal of Pediatric Emergency and Intensive Care Medicine is indexed in **Emerging Sources Citation Index (ESCI), Tübitak-ULAKBİM TR Dizini, Directory of Open Access Journals (DOAJ), Scopus, CINAHL Complete, Gale, ProQuest, Embase, Directory of Research Journal Indexing (DRJI), J-Gate, Livivo-German National Library of Medicine (ZB MED), BASE - Bielefeld Academic Search Engine, Ulrich's Periodicals Directory, EBSCO Host, IdealOnline, Türkiye Atıf Dizini, Hinari, GOALI, ARDI, OARE, AGORA, WorldCat, CNKI** and **Türk Medline**. The journal is published online.

Owner: Turkish Society of Pediatric Emergency and Intensive Care Medicine

Responsible Manager: Hayri Levent Yılmaz

Derginin "Dergi Politikaları" ve "Yazarlara Talimatlar" konularında bilgi almak için lütfen web sayfasına (<https://www.caybdergi.com/>) başvurun. Derginin editöryal ve yayın süreçleri ile etik kuralları ICMJE, COPE, WAME, CSE ve EASE gibi uluslararası kuruluşların kurallarına uygun olarak şekillenmektedir. Çocuk Acil ve Yoğun Bakım Dergisi, **Emerging Sources Citation Index (ESCI), Tübitak-ULAKBİM TR Dizini, Directory of Open Access Journals (DOAJ), Scopus, CINAHL Complete, Gale, ProQuest, Embase, Directory of Research Journal Indexing (DRJI), J-Gate, Livivo-German National Library of Medicine (ZB MED), BASE - Bielefeld Academic Search Engine, Ulrich's Periodicals Directory, EBSCO Host, IdealOnline, Türkiye Atıf Dizini, Hinari, GOALI, ARDI, OARE, AGORA, WorldCat, CNKI** ve **Türk Medline** tarafından indekslenmektedir. Dergi, çevrimiçi olarak yayınlanmaktadır.

Sahibi: Türk Çocuk Acil Tıp ve Yoğun Bakım Derneği

Sorumlu Yönetici: Hayri Levent Yılmaz



TURKISH SOCIETY OF
PEDIATRIC EMERGENCY AND
INTENSIVE CARE MEDICINE

Journal of Pediatric Emergency and Intensive Care Medicine

Çocuk Acil ve Yoğun Bakım Dergisi

CONTENTS / İÇİNDEKİLER

Research Articles / Özgün Araştırmalar

- 1 » Salbutamol Plus Mask Oxygen Versus HFNC in Bronchiolitis**
Bronşiolitte Salbutamol Plus Maske Oksijen ve HFNC Karşılaştırması
Şule Zuhal Gürsoy Durak, Özlem Tolu Kendir, Nilgün Erkek, Ömerhan Başpınar, Ramazan Gürlü; Antalya, Türkiye
- 13 » Quantitative Measurement of Lung Radiodensity on Chest X-ray Improves Diagnosis of Foreign Body Aspirations in Children**
Direkt Akciğer Grafisinde Akciğer Radyodansitesinin Kantitatif Ölçümü Çocuklarda Yabancı Cisim Aspirasyonlarının Tanısını İyileştirir
Ayten Bilen, Fatma Ceren Sarioğlu, Efil Aydın, Serra Sabuncu, Osman Zeki Karakuş, Oktay Ulusoy, Handan Güleriyüz, Oğuz Ateş, Gülce Hakküder, Mustafa Olguner, Miraç Feza Akgür; İzmir, Türkiye
- 18 » Risk Factors in Cardiovascular Surgery in Down Syndrome Patients: Single-center Experience**
Down Sendromlu Hastalarda Kardiyovasküler Cerrahide Risk Faktörleri: Tek Merkez Deneyimi
Sinan Yavuz, Umut Berk Mercan, Selman Kesici, Ahmet Aydın, Hayrettin Hakan Aykan, Mustafa Yılmaz, Benan Bayrakçı; Ankara, Türkiye
- 23 » Short First-aid Training Improves Parental Knowledge of Pediatric Head Trauma: A Pilot Study**
Kısa İlk Yardım Eğitimi Ebeveynlerin Pediyatrik Kafa Travması Bilgisini Artırıyor: Pilot Çalışma
Semra Söngüt, Hacer Delibaş, Zehra Ünal; Çorum, Türkiye
- 32 » Clinico-etiological Profile of Poisoning in Children and Impact of Counselling on Child Care and Safety Practices - A Prospective Study from North India**
Çocuklarda Zehirlenmelerin Klinik-etiyolojik Profili ve Danışmanlığın Çocuk Bakımı ile Güvenlik Uygulamaları Üzerindeki Etkisi Kuzey Hindistan'dan İleriye Yönelik Bir Çalışma
Shikhar Gupta, Urmila Jhamb, Deepak Kumar, Pallavi Pallavi; New Delhi, Ghaziabad, India
- 39 » Pediatric Acute Liver Failure: Etiologies, Intensive Care Management, and Prognostic Trends in a Tertiary Center**
Üçüncü Basamak Bir Merkezde Pediyatrik Akut Karaciğer Yetmezliği: Etiyoloji, Yoğun Bakım Yaklaşımı ve Prognoz
Fulden Aycan, Tanıl Kendirli, Emrah Gün, Edin Botan, Zarife Kuloğlu, Ceyda Tuna Kırsaçloğlu, Meltem Koloğlu, Beyza Doğanay Erdoğan, Suat Fitöz, Erdal İnce, Deniz Balcı, Aydan Kansu; Ankara, Türkiye

Case Reports / Olgu Sunumları

- 47 » Energy Drink Associated Severe Myocardial Injury in a Child: A Case Report**
Çocukta Enerji İçeceği ile İlişkili Şiddetli Miyokardiyal Hasar: Olgu Sunumu
Bayram Bayramov, Merve Havan, Eda Eyduran, Ayşen Durak Aslan, Mehmet Gökhan Ramoğlu, Tanıl Kendirli; Ankara, Türkiye
- 52 » Hernia Inguinalis Ovarii: A Case of Groin Mass Needing Urgent Attention**
Hernia Inguinalis Ovarii: Acil Müdahale Gerektiren Kasık Kütlesi Olgusu
Rashika Mony, Prema Choudhary; Chhattisgarh, India
- 56 » Can Social Media Challenges Determine Life or Death? Two Adolescent Cases from the Pediatric Intensive Care Unit**
Sosyal Medya Meydan Okumaları Yaşamı mı Ölümü mü Belirliyor? Yoğun Bakımda İzlenen İki Ergen Olgu
Kiymet Ezgi Aydın, Fatih Battal; Çanakkale, Türkiye

Journal of Pediatric Emergency and Intensive Care Medicine

Çocuk Acil ve Yoğun Bakım Dergisi



TURKISH SOCIETY OF
PEDIATRIC EMERGENCY AND
INTENSIVE CARE MEDICINE

CONTENTS / İÇİNDEKİLER

- 62 » When the Pressure Is Not High: A Case of PRES in a Normotensive Child**
Basınç Yüksek Değilken: Normotansif Bir Çocukta PRES Olgusu
Azie Jumaatul Adawiyah Binti Nabir, Assyifaa Binti Nik Mazian, Aliyyah Mohammad Khuzaini; Nilai, Ampang, Malaysia
- Review / Derleme**
- 69 » Non-invasive Mechanical Ventilation in Children and Newborns: A Bibliometric Analysis Study and Literature Review**
Çocuklarda ve Yenidoğanlarda Non-invaziv Mekanik Ventilasyon: Bibliyometrik Analiz Çalışması ve Literatür Taraması
Sri Martuti, Annang Giri Moelyo, Hanum Ferdian, Sari Dwi Jayanti; Surakarta, Indonesia



TURKISH SOCIETY OF
PEDIATRIC EMERGENCY AND
INTENSIVE CARE MEDICINE

Journal of Pediatric Emergency and Intensive Care Medicine

Çocuk Acil ve Yoğun Bakım Dergisi

EDITORIAL / EDITORIAL

The opening issue of volume 13 arrives at a moment of remarkable momentum in our discipline. Within the span of a single week in March 2026, the Surviving Sepsis Campaign (SSC) released its second-ever pediatric-specific guidelines^{1,2} the Society of Critical Care Medicine (SCCM) published the first evidence-based framework for end-of-life care in pediatric and neonatal intensive care units,³ and the updated Pediatric Readiness in the Emergency Department joint policy statement-released in January 2026-began reshaping how emergency departments across the world prepare for critically ill children.⁴ Rarely have so many foundational documents converged in such a brief period, each carrying direct implications for the clinicians and researchers who form the readership of this journal.

The 2026 SSC Pediatric Guidelines, published simultaneously in Pediatric Critical Care Medicine and Intensive Care Medicine on March 23, 2026, represent a substantial expansion from their 2020 predecessor.^{1,2,5} The updated document now contains 61 statements-of which 20 address entirely new questions-covering recognition and management of infection, hemodynamics and resuscitation, ventilation, adjunctive therapies, and, for the first time, long-term follow-up of children who survive sepsis.¹ Among the most practice-changing recommendations are the conditional suggestion to use point-of-care cardiac and lung ultrasound (POCUS) to guide resuscitation when local training and resources allow; the recommendation against routine use of procalcitonin to guide antimicrobial de-escalation when effective stewardship programs are in place; the suggestion to target conservative oxygen saturation (SpO₂ 88-92%) rather than liberal targets (>94%) following initial resuscitation in intubated children with sepsis; and the recommendation for routine infectious diseases consultation in children with sepsis and documented bloodstream infections.^{1,2} These guidelines also formally acknowledge the 2024 Phoenix Sepsis Criteria alongside traditional definitions, reflecting the evolving landscape of pediatric sepsis identification.⁶ Importantly, the panel introduced a new category of "in our practice" statements for areas where evidence remains insufficient but clinical guidance is needed-a pragmatic approach that resonates with the daily realities of our emergency departments and intensive care units, particularly in resource-variable settings.²

One week earlier, the SCCM published its 2026 Guidelines on the Care and Management of Pediatric and Neonatal Intensive Care Patients at the End of Life-the first-ever GRADE-based guideline specifically addressing end-of-life care in pediatric critical care.³ Developed by a 21-member multidisciplinary panel including intensivists, nurses, palliative care specialists, bioethicists, and bereaved parents, this document provides five conditional recommendations and one good practice statement encompassing advance care planning, palliative care consultation, systematic symptom management, bereavement support, and health equity in end-of-life care.³ For those of us who daily witness the intersection of maximal therapeutic effort and the limits of medicine, this guideline offers not only clinical direction but also ethical grounding for conversations that remain among the most difficult in our practice.

The third landmark development-the 2026 Joint Policy Statement on Pediatric Readiness in the emergency department-was released in January 2026 by the American Academy of Pediatrics, the American College of Emergency Physicians, and the Emergency Nurses Association, with endorsement from multiple national organizations.⁴ Building on robust evidence that high levels of pediatric readiness are associated with a 76% reduction in mortality risk for critically ill children and a 60% reduction for injured children, the updated statement now extends its scope to freestanding emergency departments, emphasizes universal suicide screening in adolescents, calls for multidisciplinary review of all pediatric deaths and adverse events, and places greater emphasis on pediatric mental health preparedness.⁴ The 2026 National Pediatric Readiness Project Assessment, which opened on March 3, 2026, provides a structured framework for emergency departments worldwide to evaluate and improve their capacity to care for children-a mission that lies at the very heart of our journal's identity.

Journal of Pediatric Emergency and Intensive Care Medicine

Çocuk Acil ve Yoğun Bakım Dergisi



TURKISH SOCIETY OF
PEDIATRIC EMERGENCY AND
INTENSIVE CARE MEDICINE

EDITORIAL / EDITORIAL

It is against this backdrop of global guideline transformation that we present the current issue.

The six original research articles and four case reports in this issue collectively illustrate the breadth of challenges encountered in pediatric emergency and critical care settings across multiple countries. Gürsoy Durak et al.⁷ present a prospective comparison of high-flow nasal cannula (HFNC) therapy versus salbutamol with standard oxygen in infants with bronchiolitis, demonstrating earlier clinical improvement with HFNC as measured by serial respiratory clinical scoring—a finding that aligns with the growing body of evidence supporting HFNC as a first-line respiratory support modality in selected populations. Their observation of reduced emergency department re-admission rates with HFNC, despite longer initial hospitalization, raises important questions about how we define treatment success and whether short-term metrics adequately capture patient-centered outcomes.

Bilen et al.⁸ offer an elegant contribution to the diagnostic approach of foreign body aspiration by demonstrating that quantitative radiodensity measurement on standard chest radiography nearly doubles the detection rate of aspiration-related hyperinflation—from 42.9% to 80.7%. In an era of advanced imaging, this study reminds us that substantial diagnostic gains can be achieved through more rigorous analysis of readily available tools, an approach particularly relevant for resource-limited settings.

Yavuz et al.⁹ provide a sobering 23-year analysis of cardiovascular surgical outcomes in Down syndrome patients, identifying postoperative systemic inflammatory response syndrome and high RACHS-1 surgical risk category as the strongest predictors of mortality. Their finding that comorbidity was paradoxically associated with lower mortality—likely because the underlying cardiac defect, rather than associated conditions, drove outcomes—underscores the complexity of risk stratification in this vulnerable population.

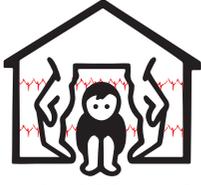
The study by Söngüt et al.¹⁰ demonstrates that even a brief 15-minute structured first-aid training session can significantly improve parental knowledge of pediatric head trauma management, with a strong effect size. This work speaks directly to the community-based preventive strategies that the updated Pediatric Readiness statement emphasizes.⁴ Gupta et al.¹¹ from North India document a shifting epidemiological pattern in childhood poisoning, with corrosive household cleaners now surpassing kerosene as the leading agent—a change that demands updated prevention strategies and public health messaging.

Aycan et al.¹² present a comprehensive single-center analysis of pediatric acute liver failure, demonstrating that toxic and drug-induced etiologies—predominantly mushroom poisoning and medication overdose—constitute the most common cause and follow a milder clinical course than other etiologies. Their 81% overall survival rate, achieved through early intensive care and timely liver transplantation, reflects the advances in multidisciplinary management that have transformed outcomes in this historically devastating condition.

The case reports in this issue carry their own urgent messages. Bayramov et al.¹³ describe severe myocardial injury in an adolescent following consumption of multiple energy drinks—a scenario increasingly encountered in pediatric emergency departments worldwide and one that demands regulatory attention and public awareness. Aydın and Battal¹⁴ present two adolescent cases illustrating the life-threatening consequences of social media “challenges”—one surviving severe hyponatremia, the other succumbing to aspiration during an eating contest—reminding us that the digital environment has become a significant source of pediatric morbidity and mortality.

The bibliometric analysis by Martuti et al.¹⁵ provides a valuable cartography of non-invasive ventilation research in children, revealing the expansion of this field from neonatal oxygenation toward broader clinical outcomes including extubation failure, weaning protocols, and mortality metrics. Their identification of Southeast Asia as an underrepresented region presents a clear opportunity for collaborative research that this journal is well-positioned to facilitate.

As we look forward, the convergence of the new SSC Pediatric Guidelines,¹ the SCCM End-of-Life Guidelines,³ and the Pediatric Readiness statement⁴ creates both a challenge and an opportunity. The challenge lies in translating these evidence-based



TURKISH SOCIETY OF
PEDIATRIC EMERGENCY AND
INTENSIVE CARE MEDICINE

Journal of Pediatric Emergency and Intensive Care Medicine

Çocuk Acil ve Yoğun Bakım Dergisi

EDITORIAL / EDITORIAL

recommendations into practice across diverse healthcare settings-from tertiary academic centers to rural emergency departments, from high-income to low- and middle-income countries. The opportunity lies in the research questions these guidelines generate: how should we implement POCUS-guided resuscitation in settings with limited training infrastructure? What are the optimal conservative oxygenation targets across different pediatric age groups and disease states? How do we integrate mental health screening into already burdened emergency department workflows? And how do we ensure that end-of-life care guidelines are culturally adaptable across the diverse communities we serve?

This journal remains committed to publishing rigorous, clinically relevant research that addresses these questions and advances the care of critically ill and injured children worldwide. I invite our readers-clinicians, researchers, and trainees alike-to engage with the work presented in this issue, to challenge its findings, and to build upon them in their own practice and scholarship.

Prof. Hayri Levent Yılmaz, MD.

Editor-in-Chief

Journal of Pediatric Emergency and Intensive Care Medicine

References

1. Weiss SL, Peters MJ, Oczkowski SJW, Belley-Cote E, Buysse C, et al. Surviving sepsis campaign international guidelines for the management of sepsis and septic shock in children 2026. *Intensive Care Med.* 2026. Epub ahead of print.
2. Weiss SL, Peters MJ, Oczkowski SJW, Belley-Cote E, Buysse C, et al. Executive summary: surviving sepsis campaign international guidelines for the management of sepsis and septic shock in children 2026. *Pediatr Crit Care Med.* 2026. Epub ahead of print.
3. Derrington S, Broden Arciprete EG, Lin MC, Oczkowski SJW, Alladin A, et al. Society of critical care medicine 2026 guidelines on the care and management of pediatric and neonatal intensive care patients at the end of life. *Pediatric Critical Care Medicine.* 2026.
4. Remick KE, Foster AA, Jensen AR, Williams RF, Stone E, et al. Pediatric readiness in the emergency department: policy statement. *Pediatrics.* 2026;157:e2025075318.
5. Weiss SL, Peters MJ, Alhazzani W, Agus MSD, Flori HR, et al. Surviving sepsis campaign international guidelines for the management of septic shock and sepsis-associated organ dysfunction in children. *Pediatr Crit Care Med.* 2020;21:e52-106.
6. Schlapbach LJ, Watson RS, Sorce LR, Argent AC, Menon K, et al. International consensus criteria for pediatric sepsis and septic shock. *JAMA.* 2024;331:665-74.
7. Gürsoy Durak ŞZ, Tolu Kendir Ö, Erkek N, Başpınar Ö, Gürlü R. Salbutamol plus mask oxygen versus HFNC in bronchiolitis. *J Pediatr Emerg Intensive Care Med.* 2026.
8. Bilen A, Sarioğlu FC, Aydın E, Sabuncu S, Karakuş OZ, et al. Quantitative measurement of lung radiodensity on chest X-ray improves diagnosis of foreign body aspirations in children. *J Pediatr Emerg Intensive Care Med.* 2026.
9. Yavuz S, Mercan UB, Kesici S, Aydın A, Aykan HH, et al. Risk factors in cardiovascular surgery in Down syndrome patients: single-center experience. *J Pediatr Emerg Intensive Care Med.* 2026.
10. Söngüt S, Delibaş H, Ünal Z. Short first-aid training improves parental knowledge of pediatric head trauma: a pilot study. *J Pediatr Emerg Intensive Care Med.* 2026.
11. Gupta S, Jhamb U, Kumar D, Pallavi P. Clinico-etiological profile of poisoning in children and impact of counselling on child care and safety practices - a prospective study from North India. *J Pediatr Emerg Intensive Care Med.* 2026.
12. Aycan F, Kendirli T, Gün E, Botan E, Kuloğlu Z, et al. Pediatric acute liver failure: etiologies, intensive care management, and prognostic trends in a tertiary center. *J Pediatr Emerg Intensive Care Med.* 2026.
13. Bayramov B, Havan M, Eyduran E, Durak Aslan A, Ramoğlu MG, et al. Energy drink associated severe myocardial injury in a child: a case report. *J Pediatr Emerg Intensive Care Med.* 2026.

Journal of Pediatric Emergency and Intensive Care Medicine

Çocuk Acil ve Yoğun Bakım Dergisi



TURKISH SOCIETY OF
PEDIATRIC EMERGENCY AND
INTENSIVE CARE MEDICINE

EDITORIAL / EDITORYAL

14. Aydın KE, Battal F. Can social media challenges determine life or death? Two adolescent cases from the pediatric intensive care unit. J Pediatr Emerg Intensive Care Med. 2026.
15. Martuti S, Moelyo AG, Ferdian H, Jayanti SD. Non-invasive mechanical ventilation in children and newborns: a bibliometric analysis study and literature review. J Pediatr Emerg Intensive Care Med. 2026.



Salbutamol Plus Mask Oxygen Versus HFNC in Bronchiolitis

Bronşiolitte Salbutamol Plus Maske Oksijen ve HFNC Karşılaştırması

Şule Zuhale Gürsoy Durak, Özlem Tolu Kendir, Nilgün Erkek, Ömerhan Başpınar, Ramazan Gürlü

Akdeniz University Faculty of Medicine, Department of Pediatric Emergency, Antalya, Türkiye

Abstract

Introduction: As the benefit of many pharmacologic treatments for bronchiolitis is a source of debate, investigations of more effective, easy-to-apply treatment modalities of acute bronchiolitis remain up-to-date.

Methods: In this study, nebulised salbutamol plus standard oxygen (S) and HFNC (HF) therapies were administered to children younger than two years of age, with a respiratory clinical score (RCS) ≥ 4 points, who presented with a first episode of acute bronchiolitis.

Results: The mean age of 72 patients was 7.8 ± 0.4 , and 59.7% were younger than six months. The mean RCS of the patients at admission was 8.42 ± 2.026 points. A significant decrease was observed in the mean RCS scores evaluated at 1-2-4-8 hours, from the first hour ($p < 0.05$). The mean length of hospital stay and duration of oxygen therapy were 70 ± 64.6 (4-288) and 67.7 ± 62.2 (4-264) hours. Within the first few days after discharge, 50% of the patients returned to the pediatric emergency department (PED). The mean RCS showed a difference in favour of the HF group from the second hour of treatment ($p = 0.002$). Expected improvement was not observed in 17.1% of the patients in the S group only, thus HF should be added. Patients in the HF group and patients in whom HF was added to S had higher hospitalisation rates ($p = 0.017$), longer hospital stays ($p = 0.002$), and longer duration of oxygen therapy ($p = 0.001$). Re-admission to PED after discharge was observed in 64.2% of the cases in the S group only ($p < 0.001$).

Conclusion: In this study, it may be said that HFNC treatment provides earlier and faster clinical improvement in children with bronchiolitis and reduces re-admissions related to the same disease.

Keywords: Acute bronchiolitis, salbutamol, high flow nasal oxygen therapy

Öz

Giriş: Bronşiolit için birçok farmakolojik tedavinin faydası tartışma konusu olduğundan, akut bronşiolit için uygulanması kolay daha etkili tedavi yöntemlerinin araştırılması konusu güncelliğini korumaktadır.

Yöntemler: Bu çalışmada; iki yaşından küçük, solunum klinik skoru (RKS) ≥ 4 puan olan ve ilk akut bronşiolit atağıyla gelen çocuklara nebulize salbutamol + artı standart oksijen(S) ve yüksek akışlı nazal kanül oksijen tedavisi (HF) tedavileri uygulandı.

Bulgular: Yetmiş iki hastanın ortalama yaşı $7,8 \pm 0,4$ idi ve %59,7'si altı aydan küçüktü. Hastaların kabul anındaki ortalama RKS'si $8,42 \pm 2,026$ puandı. İlk saatten itibaren 1-2-4-8 saatte değerlendirilen ortalama RKS skorlarında anlamlı bir düşüş gözlemlendi ($p < 0,05$). Hastanede kalış süresi ve oksijen tedavisinin süresi ortalamaları sırasıyla $70 \pm 64,6$ (4-288) ve $67,7 \pm 62,2$ (4-264) saattir. Taburcu olduktan sonraki ilk birkaç gün içinde hastaların %50'si tekrar çocuk acil servisine (PED) başvurdu. Ortalama RKS, tedavinin ikinci saatinden itibaren HF grubunun lehine farklılık gösterdi ($p = 0,002$). Sadece S grubunda hastaların %17,1'inde beklenen iyileşme görülmedi ve HF eklenmesi gerekti. HF grubundaki hastalar ve S'ye HF eklenen hastalarda daha yüksek hastane yatış oranları ($p = 0,017$), daha uzun hastanede kalış süreleri ($p = 0,002$) ve daha uzun oksijen tedavisi süreleri ($p = 0,001$) vardı. Taburcu olduktan sonra PED'ye tekrar başvuru sadece S grubunda %64,2 oranında görüldü ($p < 0,001$).

Sonuç: Bu çalışmada; HFNC tedavisinin bronşiolitli çocuklarda daha erken ve daha hızlı klinik iyileşme sağladığı ve aynı hastalığa bağlı tekrar yatışları azalttığı söylenebilir.

Anahtar Kelimeler: Akut bronşiolit, salbutamol, yüksek akımlı nazal oksijen tedavisi

Address for Correspondence/Yazışma Adresi: Assoc. Prof. Özlem Tolu Kendir, Akdeniz University Faculty of Medicine, Department of Pediatric Emergency, Antalya, Türkiye

E-mail: otolu80@yahoo.com **ORCID ID:** orcid.org/0000-0002-7580-405X

Received/Geliş Tarihi: 22.02.2025 **Accepted/Kabul Tarihi:** 10.07.2025 **Epub:** 16.07.2025 **Publication Date/Yayınlanma Tarihi:** 01.04.2026

Cite this article as: Gürsoy Durak ŞZ, Tolu Kendir Ö, Erkek N, Başpınar Ö, Gürlü R. Salbutamol plus mask oxygen versus HFNC in bronchiolitis. J Pediatr Emerg Intensive Care Med. 2026;13(1):1-12



Introduction

As the benefit of many pharmacologic treatments for bronchiolitis is a source of debate, supportive care, including supplemental oxygen for hypoxemia, is currently the mainstay of treatment for bronchiolitis.¹⁻⁴ Recently, various clinical studies have reported that the high-flow nasal cannula oxygen therapy system (HFNC) may be a safe treatment option that can improve SpO₂, respiratory rate, heart rate, and blood gas parameters in paediatric patients with acute lower respiratory tract infections.⁵⁻⁸ However, as in many parts of the world, physicians continue to manage patients in our country with their individual experiences and decisions.^{9,10}

Objective

The aim of this study is to perform a non-blind, open label, quasi-randomised, prospective crossover trial in infants under 24 months with a first clinically diagnosed bronchiolitis, comparing nebulised salbutamol plus standard mask oxygen therapy to HFNC therapy in a paediatric emergency setting in our center. The primary outcome is treatment success of salbutamol plus standard mask oxygen or HFNC therapy. Treatment success is defined as a decrease of at least two points in respiratory clinical score (RCS) scores or a downward change in the clinical severity category of the patients. Secondary outcome measures comprise (a) the rate of hospitalisation; (b) length of stay in hospital; (c) the rate of transfer of children to the pediatric intensive care unit; (d) length of oxygen therapy; (e) measurement of patients' comfort scores; (f) measurement of adverse side effects.

Materials and Methods

We included infants with the diagnosis of acute bronchiolitis that is defined as a viral respiratory infection with nasal discharge and wheezy cough, and in the presence of fine inspiratory crackles, or high-pitched expiratory wheeze on admission to the pediatric emergency room. Inclusion criteria were; infants aged ≤ 24 months with their first acute bronchiolitis attack, RCS ≥ 4 points, and/or having SpO₂ $< 94\%$ on room air, and/or having respiratory acidosis in their blood gases. Infants with previous episodes of wheezing, any chest or upper airway deformity and/or trauma limiting respiratory function, chronic (cardiac, respiratory, immunological, neurological, or metabolic) disease under treatment, and urgent need for advanced respiratory support on admission were excluded.

In our prospective clinical intervention study, patients were selected according to the pre-specified criteria mentioned above, and every 4th patient was randomized to receive HFNC oxygen therapy considering the limits of the study budget.

During the assignment of patients to treatment groups, ranking numbers were used to determine that every fourth patient would be in the HFNC group, and the total number of patients who started with and those who added HFNC treatment was restricted to the available sets. The allocation of patient to the treatment groups using method that were not truly random but intended to produce similar groups This quasi-randomization was used because true randomization was not feasible. Emergency department staff were not blinded in terms of the implementation of treatment, clinical evaluation, and scoring. Our study was planned and conducted as a pediatric resident thesis. The assistant physician and the responsible faculty member, who collected and evaluated the study data, were not involved in the treatment process and clinical evaluation of study patients. Ethical approval was obtained from the Local Clinical Researches Ethics Committee of Akdeniz University (15.11.2017-674), and the trial was overseen by a steering committee, consisting of senior pediatrics faculty members, for the ethical and rigorous conduct of the trial. Governance approval from the university hospital has been obtained. There was no registration in another clinical study system. Informed written consent was obtained from a parent of each child.

All patients were clinically evaluated for study inclusion by pediatric emergency department (PED) physicians using standard history and physical examination. The RCS system is a reliable scoring method that can be calculated quickly and easily, with 0-4 points indicating mild severity,⁵⁻⁸ points indicating moderate severity, and 9-12 points indicating severe respiratory distress clinical category.¹¹⁻¹³ The RCS takes into account the 4 parameters, namely, respiratory rate, retractions, dyspnea, and wheezing. Each parameter is scored in four steps, with scores ranging from 0 to 3 points, as shown in Figure 1. Pretrained PED physicians assessed the RCS score of patients included in the study just before the allocation, and at the 1st, 2nd, 4th, and 8th hour of treatment.

Treatment in the first group was started with HFNC, and in the second group was started with standard mask oxygen therapy and salbutamol nebulisation. If the expected response was not achieved by the end of the second hour, salbutamol nebulisation was added to HFNC in the first group, or HFNC was added to salbutamol in the second group. Support with HFNC was not removed when placing the jet nebuliser face mask, in patients requiring a change in therapy. The PED physician deemed a treatment change was required; if RCS scores of the patient were not decreased by at least two points, or increased above baseline, and/or if a downward change in the clinical severity category was not achieved and/or if there was further decrease or no improvement in SpO₂ measurements, or if the patient showed obvious non-compliance with the treatment. After commencing the trial,

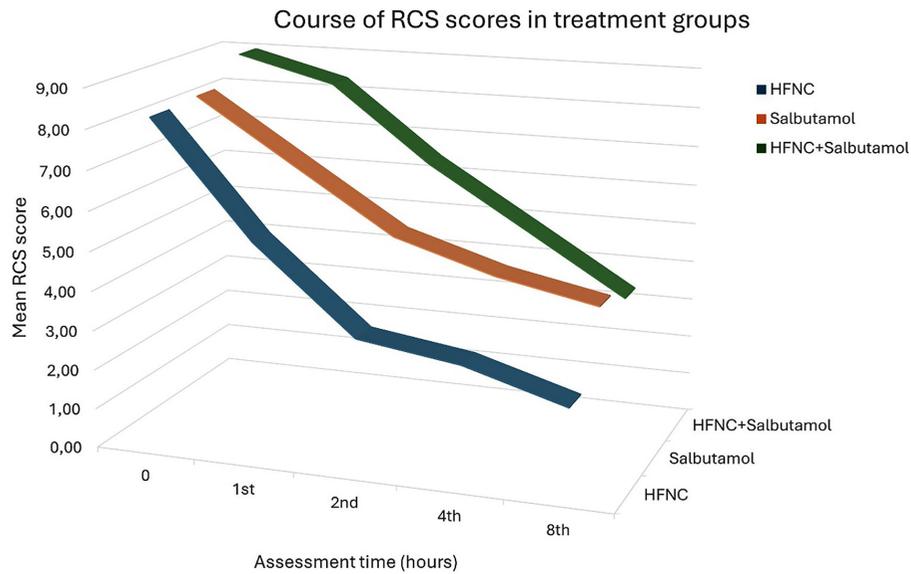


Figure 1. Course of RCS scores in treatment groups
RCS: Respiratory clinical score, HFNC: High-flow nasal cannula oxygen therapy system

| Respiratory clinical scoring tool | | | Assessment time (hour) | | | | |
|------------------------------------|---|-------------------|------------------------|-----------------|-----------------|-----------------|-----------------|
| Variables | Features | Points | 0 | 1 st | 2 nd | 4 th | 8 th |
| Respiratory rate/min | <30 | 0 | | | | | |
| | ≤45 | 1 | | | | | |
| | ≤60 | 2 | | | | | |
| | >60 | 3 | | | | | |
| Retractions (Work of breathing) | None | 0 | | | | | |
| | Subcostal OR intercostal | 1 | | | | | |
| | At least 2 of them subcostal/intercostal/substernal OR nazal flaring | 2 | | | | | |
| Dyspnea (Shortness of breath) | At least 3 of them subcostal/intercostal/substernal/supraclavicular OR nazal flaring/head bobbing | 3 | | | | | |
| | Normal feeding vocalizations and activity | 0 | | | | | |
| | Any of them difficulty feeding decreased vocalization OR agitated | 1 | | | | | |
| Wheezing | At least 2 of them difficulty feeding decreased vocalization OR agitated | 2 | | | | | |
| | None | 0 | | | | | |
| | Any of them stops feeding no vocalization drowsy OR confused | 3 | | | | | |
| End-expiratory wheeze only | End-expiratory wheeze only | 1 | | | | | |
| | Long lasting OR whole expiratory wheeze | 2 | | | | | |
| | Inspiratory and expiratory wheeze OR diminished breath sounds OR both | 3 | | | | | |
| Total RCS score* | Time 0: 1 st : 2 nd : | 4 th : | 8 th : | | | | |
| Heart rate/min** | ≤150 | 0 | | | | | |
| | ≤160 | 1 | | | | | |
| | ≤170 | 2 | | | | | |
| | >170 | 3 | | | | | |
| Saturation SpO ₂ %** | ≥95 | 0 | | | | | |
| | ≥94 | 1 | | | | | |
| | ≥90 | 2 | | | | | |
| | <90 | 3 | | | | | |

*: Based on the total score obtained there can be 3 clinical categories of respiratory distress Mild (0-4) Moderate (5-8) Severe (9-12)
 **: Heart rate and saturation SpO₂ are evaluated separately apart from scoring

RCS scores were evaluated at 0, 1, 2, 4, and 8 hours, along with hourly vital signs and SpO₂% measurements of the patients.

Implementations and Protocols

HFNC therapy

Heated and humidified HFNC oxygen is delivered via Airvo 2 device, through an Optiflow junior infant size cannula (OPT316) of Fisher & Paykel Healthcare. Initial settings were 2 L/kg/min flow and 100% inspiratory oxygen fraction (FiO₂); then, according to physician's clinical judgement, flow rate increments of 2 L/min (to a maximum of 25 L/min) were made at quarter-hour intervals and FiO₂ titrated to ≤40% to maintain SpO₂ ≥95%. All patients received standard care at the discretion of PED physicians. To wean the treatment, patients who achieved RCS <4 points for at least 8 hours under HFNC therapy underwent a gradual reduction of the flow rate by 10-25%. They were monitored for 2 hours after each change. If the infant was clinically stable and able to maintain saturations ≥95% for at least 2 hours after the flow rate decreased below 4 L/min, HFNC therapy was ceased and the patient was switched to low flow oxygen therapy with a mask. Oxygen support was turned off completely once a patient receiving standard oxygen therapy with a mask remained stable and maintained SpO₂ ≥95% for at least four hours.

Salbutamol treatment

Salbutamol was given 0.15 mg/kg (maximum 2.5 mg/dose), every 4 hours at most, using the small-volume jet nebuliser via face mask with 5-10 L/min oxygen flow supplied to the device. Patients were given low-flow (5-10 L/min) oxygen support with a simple mask to maintain SpO₂ ≥95 between treatments.

COMFORT Behaviour Scale (CBS)

CBS is a measurement tool to assess pain, distress, and sedation in pediatric patients under a variety of respiratory supports. The CBS, scored out of 30 points in total, indicates optimal patient comfort between 11 and 22 points; ≥23 points are interpreted as insufficient comfort, while ≤10 points indicate excessive sedation.¹⁴⁻¹⁷ PED nurses assessed comfort, calmness, and tolerability of the patients during both HFNC and salbutamol nebulisation therapies within half an hour of initiating each treatment. The assessment was done once by a pre-trained nurse, who waited for 10-15 minutes for the child to get used to the environment and the practice. Total CBS was calculated by scoring 6 behavioural parameters, such as alertness, calmness/agitation, respiratory response, physical movement, muscle tone, and facial expression, assigning each a score of 1-5 points.

The physicians and nurses working in the PED were informed about the study protocol in advance and trained for scoring evaluation.

The history and examination findings of all patients at the time of admission; hourly temperature, saturation, heart rate, blood pressure, and respiratory rate; and the RCS scores calculated at 0-1-2-4-8 hours of the treatment were recorded on the prepared forms. CBS points, as well as any side effects, problems, and complications observed during the treatments, were also recorded. The patients' file records were accessed, and respiratory viral agents, laboratory results (haemogram, blood gases, C-reactive protein, procalcitonin, blood electrolytes, and glucose), and history of recurrent bronchiolitis in clinical follow-up, which were available, were recorded on the data collection forms. The length of stay in hospital and intensive care unit was recorded. Patients were contacted by telephone within the first 7 days after discharge and asked about persistence of symptoms and any history of readmission to the hospital or PED within a few days.

Statistical Analysis

Based on previous studies we estimated treatment failure rates of different modalities were 7-20% in infants with bronchiolitis.⁴ An unequal distribution of a sample size involving 72 infants is necessary to have ≥80% power at a 5% significance level to assess the difference between two treatment modalities (Suresh KP, Chandrashekhara S. Sample size estimation and power analysis for clinical research studies. *J Hum Reprod Sci* 2012;5:7-13).

SPSS V.23 was used for data entry; continuous data were presented as mean and standard deviation (SD) or median and interquartile range (IQR) depending on variable distribution; categorical data were presented using number and percentage. X², Mann-Whitney U test, dependent sample t-test, Spearman's rho pairwise correlation analyses, related samples Friedman's Two-Way Analysis and Kruskal-Wallis test and One-Way ANOVA test with applying Bonferroni adjustment of repeated measurements were used in the comparisons between the treatment groups according to the characteristics of the variables with a significant p-value <0.05.

Results

Seventy-two children who were followed up in the emergency department of a university hospital, which has an annual admission of 45,000 pediatric patients, between 01.10.2018 and 31.03.2019 and who met the criteria were included in the study. A total of 229 eligible patients with acute bronchiolitis were identified during this period. Of these, 157 were excluded due to RCS <4 points, recurrent bronchiolitis,

the presence of other comorbidities, or family refusal (summarized in Figure 2).

Of the 72 patients included in the study, 59.7% were under 6 months at admission, and their mean age was 7.8 ± 0.4 months. The whole study group was evaluated altogether, the mean initial RCS was 8.42 ± 2.02 points, and half of the patients were considered to have bronchiolitis with serious clinical severity ($RCS > 8$). A significant decrease in the mean RCS scores of the patients was observed within hours under treatment (6.82 ± 1.92 , 5.13 ± 2.20 , 4.28 ± 2.29 , 3.58 ± 2.37 points at 1, 2, 4, and 8 hours, respectively) ($p < 0.05$). A decrease of at least 2 points from the baseline was achieved in RCS scores at the second and fourth assessment hours in 85.3% and 98.5% of the patients, respectively. 51.4% of the patients were hospitalised in the ward and 4.2% in the intensive care unit. No patient died in the study group. The mean length of hospital stay was 70 ± 64.6 hours; 50% of the patients were readmitted to PED with respiratory complaints within the first few days following discharge; and 59.7% had bronchiolitis again in the 20-month follow-up. Children who were readmitted to PED or hospital in the early period had recurrent episodes of bronchiolitis during follow-up ($p = 0.002$).

The initial treatment groups [HFNC (HF) and salbutamol+mask oxygen (S)] were similar in terms of socio-demographic and clinical characteristics except that a higher proportion of children in the HFNC group came from crowded families

($p = 0.014$). Socio-demographic characteristics and clinical and laboratory findings of the initial treatment groups are given in Tables 1a and 1b.

The mean heart rate of the patients decreased below 150 beats/min, which is the tachycardia limit value in children under 2 years of age, and the mean respiratory rate decreased below 50/min, which is the tachypnoea limit value, at the 1st hour in the HF group and after the 4th hour in the S group.¹⁸ HFNC had to be added to the treatment, in 17.1% of those whose treatment was started with salbutamol plus mask oxygen, whereas no treatment change was required in any patient in the HFNC group. Among the patients in group S, those who required HFNC, 90.9% were older than 6 months, 81.8% had a baseline RCS > 10 points, and 72% had hypoxia in blood gases. Having older patients' age ($p = 0.00$), higher RCS scores at 1st and 2nd hours ($p = 0.001$ and 0.025), wheezing at 2nd hour ($p = 0.003$), and higher retraction scores at 1st to 4th hours ($p = 0.005$ and 0.02) made a significant difference in terms of treatment change. The courses of clinical characteristics and outcomes of patients in three treatment groups are given in Tables 2a-d. Patients who were initially treated with HFNC

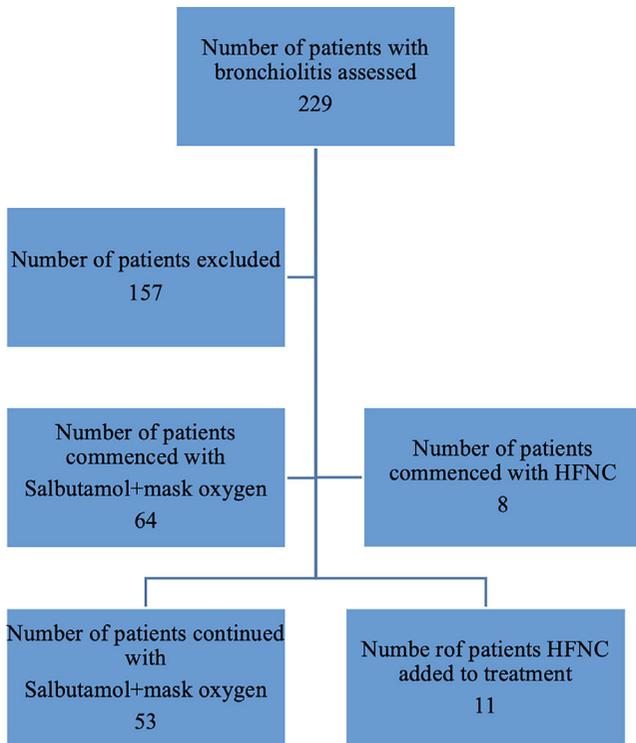


Figure 2. A flowchart showing numbers of patients assessed, excluded from the study and included into treatment groups
HFNC: High-flow nasal cannula oxygen therapy system

Table 1a. Socio-demographical features of initial study groups

| Parameter | HFNC (n=8) n (%) | Salbutamol (n=64) n (%) | p-value |
|---|---------------------|----------------------------|---------|
| Gender | | | |
| Female | 3 (37.5) | 22 (34.4) | |
| Male | 5 (62.5) | 42 (65.6) | 1 |
| Age (months) | | | |
| 0-3 | 2 (25) | 17 (26.6) | |
| 4-6 | 1 (12.5) | 23 (35.9) | |
| 7-12 | 2 (25) | 14 (21.9) | |
| 13-24 | 3 (37.5) | 10 (15.6) | 0.385 |
| Prematurity <36 weeks | 2 (25) | 13 (20.3) | 0.669 |
| Caesarean birth | 7 (87.5) | 45 (70.3) | 0.429 |
| Respiratory support in neonatal period | 2 (25) | 10 (15.6) | 0.613 |
| Exclusive breast feeding for the first 6 months | 4 (50) | 43 (67.2) | 0.436 |
| Regular prophylactic use of vitamin D | 5 (62.5) | 53 (86.9) | 0.106 |
| Age-appropriate vaccination | 7 (87.5) | 64 (100) | 0.111 |
| Care in a day-care center | 0 (0) | 6 (9.4) | 1 |
| History of food allergy/eczema in child | 2 (25) | 10 (15.6) | 0.613 |
| Family history of asthma | 4 (50) | 24 (37.5) | 0.703 |
| Smoking history at home | 5 (62.5) | 34 (53.1) | 0.719 |
| Crowded family environment | 6 (75) | 18 (28.1) | 0.014 |
| Low economical level | 0 (0) | 13 (20.3) | 0.336 |

HFNC: High-flow nasal cannula oxygen therapy system

and took the (HF+S) treatments were evaluated together (15/19 patients, 79%); it was observed that more patients were hospitalized from this group (p=0.017) than from the S group (25/53 patients, 48%). Length of hospital stay was significantly longer in patients whose treatment was started with HFNC and/or had HFNC (p=0.002). In 3 patients younger than 2 months, hospitalized in the pediatric intensive care unit, 2 of whom were male, the RCS were 9 and 10, and one of them was followed under HFNC. Two of the three patients who were discharged after 72-168 hours of follow-up returned to PED in the early period; both were in the salbutamol group. Readmission to PED was significantly higher in the salbutamol group because of persistent complaints in the first few days after discharge (p=0.00). No complications related to treatment interventions were observed in any patient in the study groups.

Table 1b. Clinical and laboratory findings of initial study groups

| Parameter | HFNC (n=8) n (%) | Salbutamol (n=64) n (%) | p-value |
|--|------------------------|-------------------------------|---------|
| Complaints at admission | | | |
| Cough | 6 (75) | 43 (67.2) | |
| Respiratory distress | 2 (25) | 16 (25) | |
| Fever and the others* | 0 (0) | 5 (7.8) | 1 |
| Examination findings at admission | | | |
| Fever >38 °C | 3 (37.5) | 9 (14.1) | 0.123 |
| Tachypnoea >50/min | 5 (62.5) | 49 (76.6) | 0.404 |
| Tachycardia >150/min | 6 (75) | 48 (75) | 1 |
| Desaturation <95% | 2 (25) | 14 (21.9) | 1 |
| Dyspnoea | 8 (100) | 59 (92.1) | (0.658) |
| Retractions | 8 (100) | 60 (93.7) | 0.764 |
| Wheezing | 8 (100) | 62 (97.9) | 0.063 |
| Others** | 2 (25) | 9 (14.1) | 0.412 |
| Laboratory findings at admission*** | | | |
| Anemia <10 gr/dL | 1 (14.3) | 17 (27.9) | 0.666 |
| Leukocytosis >15.000/mm ³ | 1 (14.3) | 12 (19.7) | 0.706 |
| CRP >2 mg/dL | 1 (12.5) | 9 (14.1) | 0.836 |
| Acidosis (pH <7.35) | 1 (12.5) | 13 (22) | 0.518 |
| Hypercarbia (pCO ₂ >45 mmHg) | 0 (0) | 5 (8.5) | 0.462 |
| Respiratory clinical score at admission | | | |
| 4-8 points | 6 (75) | 31 (48.4) | |
| 9-12 points | 2 (25) | 33 (51.6) | 0.262 |
| Comfort behaviour score (n=33/72 45.8%) | | | |
| Over-sedation 10 points | 3 (37.5) | 6 (24) | |
| Optimal comfort 11-22 points | 5 (62.5) | 15 (60) | |
| Inadequate comfort 23 points | 0 (0) | 4 (16) | 0.429 |
| *: Diarrhea vomiting sore throat runny nose, **: Rales dehydration increased anterior-posterior chest diameter oropharyngeal hyperemia tonsillar hypertrophy plus postnasal serous discharge, ***: Venous blood gasses were obtained in 67/72 patients (93%) hemogram was obtained in 68/72 patients (94%), HFNC: High-flow nasal cannula oxygen therapy system, CRP: C-reactive protein | | | |

The mean CBS score evaluated in a total of 33 children was 13.9±5.1 points, indicating the optimal comfort level (between 11-22 points) in 60.6% of those examined. It was not applied to all patients because pre-trained nurses were not on duty or the PED was overcrowded and the evaluation period had passed. CBS did not differ according to patients' age, clinical disease severity, initial RCS scores, and treatment modalities (mean ± SD, min-max CBS: 18-6, 4.64±12.13 points in HF group and 24-7, 5.25±14.56 points in S group, p=0.330) of the patients (p>0.05).

Discussion

In this single-centre prospective clinical intervention study, we compared the effects of HFNC with nebulised bronchodilator and standard oxygen therapy, on the clinical course of infants, mostly younger than 6 months, in our emergency department follow-up presenting with a first episode of bronchiolitis of moderate to severe clinical severity Prospective hourly follow-up for 8 hours in PED, and re-evaluated with objective clinical scoring are the strengths of the study. As a weakness of the study, due to the small number of participants, results should be interpreted with caution.

RCS scoring has been defined as a reliable tool.¹¹ In this sense, with repeated examinations, the RCS may help the clinician to determine the severity of bronchiolitis, need for hospitalisation, follow-up of treatment response, change, and or addition of treatment, and need for intensive care by providing non-invasive objective evaluation that is not based on clinical experience.¹⁷ In the present study, patients were significantly relieved earlier in the HF group compared to the S group in terms of RCS scores, clinical severity category, heart rate, respiratory rate, wheezing, and chest retractions, which are indicators of respiratory distress in bronchiolitis. In this study, although the mean heart rate of the patients decreased below 150 beats/min, and the mean respiratory rate decreased below 50/min at the 1st hour in the HF group and after the 4th hour in the S group, the improvement in the mean heart rate from the first hour and in the mean respiratory rate only at the 8th hour was statistically significant in favour of the HF group. Consistent with these findings, in infants diagnosed with bronchiolitis and pneumonia who were treated with HFNC and did not need a change in treatment, many studies in the literature have emphasized that the clinical evaluation criteria for response to treatment include improvements in SpO₂% and S/F ratio, RCS from the first hour, and regression of tachycardia in the early period.^{10,19-24} On the other hand, there are studies reporting that improvement in respiratory rates was achieved over a longer period ranging from 1 to 6 hours under HFNC treatment.^{5,19-23} Although the present study was limited by a small number of patients, it may be

Table 2a. Course of RCS scores and heart and respiratory rates under treatment

| Parameter | Treatment groups | | | | p-value |
|-----------|----------------------|-----------------------------|-----------------------------|-----------------------------|---------|
| | Evaluation time | HFNC (n=8) | Salbutamol (n=53) | Salbutamol + HFNC (n=11) | |
| | | Mean ± SD (95% CI for mean) | Mean ± SD (95% CI for mean) | Mean ± SD (95% CI for mean) | |
| RCS score | 0. hour | 8.25±1.16 (7.28-9.22) | 8.32±1.97 (7.78-8.87) | 9.00±2.72 (7.17-10.83) | 0.588 |
| | 1 st hour | 5.38±1.40 (4.20-6.55) | 6.72±1.75 (6.23-7.20) | 8.36±2.11 (6.95-9.78) | 0.031 |
| | 2 nd hour | 3.25±1.03 (2.38-4.12) | 5.13±1.86 (4.62-5.65) | 6.45±3.32 (4.22-8.69) | 0.006 |
| | 4 th hour | 2.88±1.55 (1.58-4.17) | 4.36±2.11 (3.78-4.94) | 4.91±3.23 (2.73-7.09) | 0.008 |
| | 8 th hour | 2.13±1.95 (0.49-3.76) | 3.85±2.24 (3.22-4.47) | 3.36±3.00 (1.34-5.39) | 0.002 |
| RR/min | 0. hour | 57.0±13.0 (46.1-7.8) | 61.8±13.4 (58.1-65.5) | 62.7±12.8 (54.1-71.3) | 0.595 |
| | 1 st hour | 47.3±15.1 (34.7-60.0) | 56.4±11.6 (53.2-59.6) | 56.8±11.3 (49.2-64.4) | 0.134 |
| | 2 nd hour | 46.7±14.5 (34.5-58.9) | 52.3±9.8 (49.5-55.0) | 54.7±19.8 (41.3-68.0) | 0.37 |
| | 4 th hour | 46.3±18.43 (30.96-61.79) | 48.66±10.07 (45.88-51.44) | 48.73±19.66 (35.52-61.94) | 0.894 |
| | 8 th hour | 37.25±18.9 (21.4-53.0) | 44.7±9.8 (41.9-47.4) | 43.6±14.3 (43.0-53.2) | 0.263 |
| HR/min | 0. hour | 161.8±14.8 (149.4-174.2) | 160.7±16.6 (156.1-165.2) | 154.6±44.6 (124.6-184.6) | 0.702 |
| | 1 st hour | 142.5±15.2 (129.7-155.2) | 158.2±16.9 (153.5-162.9) | 145.1±49.7 (111.7-178.6) | 0.053 |
| | 2 nd hour | 142.8±27.6 (119.8-165.9) | 158.4±21.0 (152.5-164.2) | 148.3±25.4 (131.2-165.4) | 0.113 |
| | 4 th hour | 133.5±22.2 (114.9-152.0) | 151.7±18.0 (146.7-156.7) | 135.6±21.6 (121.0-150.1) | 0.006 |
| | 8 th hour | 119.0±23.2 (99.6-138.4) | 142.5±15.8 (138.2-146.9) | 126.1±23.2 (110.5-140.8) | 0 |

RCS: Respiratory clinical score, RR: Respiratory rate, HR: Heart rate, HFNC: High-flow nasal cannula oxygen therapy system, CI: Confidence interval, SD: Standard deviation

said that the clinical severity in infants with a first attack of bronchiolitis was relieved more rapidly with HFNC. Similarly, in a systematic review study which embraces 14 research articles on HFNC usage in pediatric emergency setting, Yurtseven et al.²⁴ reported that HFNC therapy was better than standard oxygen therapy and was at least as effective as other supports of non-invasive ventilation.

When the entire study group was evaluated together, 85.3% and 98.5% of the patients had at least a 2-point decrease in the mean RCS score at the second and fourth assessment hours, respectively, compared to the baseline. In addition, a significant difference was found in the mean RCS scores of the HF and S treatment groups from the 2nd hour onwards. In this respect, it is reasonable to conclude that in infants with moderate to severe bronchiolitis, it is rational and guiding to assess treatment failure, modifications, and the need for additional treatment (excluding clinical deterioration). This assessment can be conducted at the 2nd hour at the earliest based on the RCS score after the initiation of treatment. In a prospective pilot study, Mayfield et al.⁵ compared HFNC with standard oxygen therapy in infants under 1 year of age with bronchiolitis, with one quarter of the infants in both groups

receiving salbutamol therapy simultaneously. They reported that in patients who did not respond to treatment, heart rate and respiratory rate were significantly higher at 3 hours, with an increasing trend in respiratory rate >50/min, and heart rate >150/min.¹⁰ Similarly, in a multicentre prospective randomised study, tachycardia, tachypnoea, persistent and gradually increased oxygen requirements between the 2nd and 3rd hours of follow-up were taken as criteria in determining treatment failure and the need for additional treatment.²⁵ In another study from Türkiye, the presence of persistent tachypnoea and tachycardia after the second hour in patients who did not respond to treatment was highlighted.²⁵

In the study group, 15.2% of the patients required treatment modification because the expected improvement was not achieved. Although all of the patients whose treatment was changed were in the S group (17.1%), the difference between the groups did not reach statistical significance due to the small number of patients in the HF group. Patients who underwent treatment change had significantly higher scores for RCS points, wheezing, and retraction at the 2nd assessment hour and afterwards. Consistent with this, a multicentre prospective randomised controlled PARIS study

Table 2b. Course of RCS sub parameters under treatment

| Parameter | Evaluation time | | HFNC (n=8) n (%) | Salbutamol (n=53) n (%) | Salbutamol + HFNC (n=11) n (%) | p-value | |
|----------------------|----------------------|-----------------|---------------------|----------------------------|-----------------------------------|----------|-------|
| Retraction | 0. hour | Mild | 1 (12.5) | 16 (30.2) | 1 (9.1) | 0.322 | |
| | | Moderate-severe | 7 (87.5) | 37 (67.8) | 10 (90.9) | | |
| | 1 st hour | Mild | 3 (37.5) | 25 (47.2) | 1 (9.1) | 0.061 | |
| | | Moderate-severe | 5 (67) | 28 (52.8) | 10 (90.1) | | |
| | 2 nd hour | Mild | 7 (87.5) | 39 (73.6) | 3 (27.3) | 0.004 | |
| | | Moderate-severe | 1 (12.5) | 14 (26.4) | 8 (72.7) | | |
| | 4 th hour | Mild | 7 (87.5) | 43 (81.1) | 4 (36.4) | 0.009 | |
| | | Moderate-severe | 1 (12.5) | 10 (18.9) | 7 (83.6) | | |
| | 8 th hour | Mild | 0 | 45 (84.9) | 7 (63.6) | 0.121 | |
| | | Moderate-severe | 8 (100) | 8 (15.1) | 4 (37.4) | | |
| | Dyspnoea | 0. hour | Mild | 3 (37.5) | 20 (37.7) | 2 (18.2) | 0.509 |
| | | | Moderate-severe | 5 (62.5) | 33 (62.3) | 9 (81.9) | |
| 1 st hour | | Mild | 7 (87.5) | 26 (49.1) | 4 (36.4) | 0.075 | |
| | | Moderate-severe | 1 (12.5) | 27 (50.9) | 7 (63.6) | | |
| 2 nd hour | | Mild | 7 (87.5) | 35 (66) | 7 (63.6) | 0.508 | |
| | | Moderate-severe | 1 (12.5) | 18 (34) | 4 (37.4) | | |
| 4 th hour | | Mild | 7 (87.5) | 38 (71.7) | 8 (72.7) | 0.824 | |
| | | Moderate-severe | 1 (12.5) | 15 (28.3) | 3 (27.3) | | |
| 8 th hour | | Mild | 7 (87.5) | 41 (77.4) | 9 (81.8) | 1 | |
| | | Moderate-severe | 1 (12.5) | 12 (23.6) | 2 (18.2) | | |
| Wheezing | 0. hour | Mild | 3 (37.5) | 8 (15.1) | 2 (18.2) | 0.317 | |
| | | Moderate-severe | 5 (62.5) | 45 (84.9) | 9 (81.8) | | |
| | 1 st hour | Mild | 5 (62.5) | 24 (45.3) | 2 (18.2) | 0.129 | |
| | | Moderate-severe | 3 (37.5) | 29 (54.7) | 9 (81.8) | | |
| | 1 st hour | Mild | 8 (100) | 39 (73.6) | 7 (63.6) | 0.02 | |
| | | Moderate-severe | 0 | 14 (27.4) | 4 (37.4) | | |
| | 2 nd hour | Mild | 8 (100) | 40 (75.5) | 5 (45.5) | 0.479 | |
| | | Moderate-severe | 0 | 13 (24.5) | 6 (54.5) | | |
| | 4 th hour | Mild | 8 (100) | 41 (77.4) | 10 (90.9) | 0.509 | |
| | | Moderate-severe | 0 | 12 (23.6) | 1 (9.1) | | |

Mild takes 0 OR 1 points, Moderate-severe takes 2 OR 3 points. RCS: Respiratory clinical score, HFNC: High-flow nasal cannula oxygen therapy system

comparing HFNC and nasal low-flow oxygen treatments in infants with bronchiolitis under one year of age showed that treatment failure was twice as high in the standard nasal oxygen group (12% vs. 23%). Persistent tachycardia (56% and 69%), tachypnoea (72% and 76%), and high clinical assessment scores (77% and 78%) were found in both groups in a significant proportion of patients requiring treatment change. Franklin et al.²² reported that successful results were obtained in 62% of patients switched from standard treatment to HFNC. This literature supports the results that there was no need to switch to another advanced treatment or intensive care unit admission for patients in our study group who received HFNC as part of their treatment modification.

The whole study group was evaluated together. The mean hospital stay of the patients was found to be 70 hours, which is similar to the literature.²⁶⁻²⁸ However, patients in the present study whose treatment was started with HF and then continued with additional HF were hospitalised at a significantly higher rate and stayed in hospital for longer periods, as recently reported in a multicenter prospective study.²⁹ Although some reports on the use of HFNC at home have begun to be included in literature recently, the safety of home use is controversial.³⁰⁻³³ Another issue that has not been fully clarified in HFNC therapy is the weaning protocol. As applied in our hospital, the recommendations in the literature include stepwise, controlled tapering schemes spread over extended hours. These rationales may explain

Table 2c. Patients' outcomes and course of clinical respiratory severity categories under treatment

| Parameter | Evaluation | HFNC (n=8) | Salbutamol (n=53) | Salbutamol + HFNC (n=11) | p-value |
|---|----------------------|------------|-------------------|--------------------------|---------|
| | | n (%) | n (%) | n (%) | |
| Clinical respiratory severity category* | 0. hour | | | | |
| | Moderate | 6 (75) | 28 (52.8) | 3 (27.3) | 0.12 |
| | Severe | 2 (25) | 25 (47.2) | 8 (72.7) | |
| | 1 st hour | | | | |
| | Mild | 1 (12.5) | 2 (3.8) | 0 (0) | 0.001 |
| | Moderate | 7 (87.5) | 44 (83) | 4 (36.4) | |
| | Severe | 0 (0) | 7 (13.2) | 7 (63.6) | |
| | 2 nd hour | | | | |
| | Mild | 4 (50) | 12 (22.6) | 3 (27.3) | 0.034 |
| | Moderate | 4 (50) | 39 (73.6) | 4 (36.4) | |
| | Severe | 0 (0) | 2 (3.8) | 4 (36.4) | |
| | 4 th hour | | | | |
| | Mild | 5 (62.5) | 23 (43.4) | 4 (36.4) | 0.195 |
| | Moderate | 3 (37.5) | 30 (56.6) | 6 (54.5) | |
| | Severe | 0 (0) | 0 (0) | 1 (9.1) | |
| 8 th hour | | | | | |
| Mild | 6 (75) | 29 (55.8) | 6 (54.5) | 0.332 | |
| Moderate | 2 (25) | 23 (44.2) | 4 (36.4) | | |
| Severe | 0 (0) | 0 (0) | 1 (9.1) | | |
| Patients' outcome in PED | Hospitalized | 2 (25) | 28 (52.8) | 2 (18.2) | 0.062 |
| | Outpatient | 6 (75) | 25 (47.2) | 9 (18.8) | |
| Re-admission to PED | Yes | 0 | 34 (64.2) | 2 (18.2) | 0 |

*: Mild: Takes 0-4 points, Moderate: takes 5-8 points, Severe: Takes 9-12 points, PED: Pediatric emergency department, HFNC: High-flow nasal cannula oxygen therapy system

Table 2d. Patients' treatment times

| Parameter | Treatment groups | | | p-value |
|----------------------------------|-----------------------------|-----------------------------|-----------------------------|---------|
| | HFNC (n=8) | Salbutamol (n=53) | Salbutamol + HFNC (n=11) | |
| | Mean ± SD (95% CI for mean) | Mean ± SD (95% CI for mean) | Mean ± SD (95% CI for mean) | |
| Length of hospital stay, hours | 97.0±58.3 (48.1-145.8) | 56.2±59.0 (39.9-72.5) | 116.7±71.6 (68.5-164.8) | 0.007 |
| Duration of oxygen uptake, hours | 97.0±58.3 (48.1-145.8) | 54.9±57.7 (39.0-70.8) | 107.6±66.9 (62.6-152.6) | 0.012 |

HFNC: High-flow nasal cannula oxygen therapy system, SD: Standard deviation, CI: Confidence interval

the higher rate and longer duration of hospitalization of the patients in the HF group.^{8,34-38} However, due to presence of a very wide distribution range and large SD necessitate careful interpretation of the comparison results for length of hospital stay.

In the present study group, 50% of the patients presented to the PED again with respiratory complaints within the first few days following discharge. There was no difference between patients whose treatment was continued at home (47.5%) and those who were hospitalised (42.5%) in terms of readmission to PED. The fact that one third of the study group consisted

of infants younger than 3 months and more than half of them were boys, as well as the fact that one out of every two infants was exposed to smoking at home, may explain the high rate of readmission to the emergency department. In addition, families may have been more concerned about their previously healthy infants who had their first episode of bronchiolitis. We did not evaluate the outcome of re-visits to PED in our study. In our study group, HFNC therapy seemed to be significantly advantageous in terms of the need for readmission to PED. In the literature, return visits to the hospital within 3 to 30 days following discharge in children who were

hospitalized and treated for acute bronchiolitis, or whose treatment was continued at home after observation in the emergency department, have been reported as 23.8-34.2%. Readmissions to the hospital have been reported as 3.7-8%, respectively. It was emphasized that most of the return visits were due to prolonged recovery from bronchiolitis rather than clinical worsening. Also, supporting present study findings, it has been demonstrated that factors such as age <3 months, male sex, respiratory syncytial virus positivity, and exposure to cigarette smoke may increase the risk for readmission to PED and re-hospitalisation in infants with bronchiolitis.³⁹⁻⁴⁴

Acute bronchiolitis shows a course in which the most intense symptoms are seen in the first 3-4 days, gradually decreasing and mostly improving in 7-14 days.^{39,45} Patients in group S, who had a shorter duration of inpatient hospitalisation, may have returned to PED with respiratory complaints during the period spent at home. However, it has also been reported in the literature that the number of days of inpatient treatment has no effect on the frequency of readmission.⁴⁵ On the other hand, there may be a difference due to the small number of patients in group HF. In this regard, evaluation based on the study group's data would be insufficient and is a limitation.

The CBS of the initial treatment modalities did not differ statistically in the present study, which may be another restriction due to the number of patients. In a recent study, it was reported that comfort and satisfaction in children with bronchiolitis were greater with HFNC,⁴⁶ as observed by both nurses and parents. However, in detail, median CBS scores in those groups (13, IQR 9-15 vs. 17, IQR 13-23) both indicate optimal comfort levels as observed in our present study.

Study Limitations

Although the results show that HFNC treatment provides rapid clinical improvement in infants with first acute bronchiolitis, the small number of participants is a limitation of this study. Constraints of the study budget limited the number of patients in the HFNC treatment group. The small sample size in the HFNC group is the main weakness of this study that might diminish statistical power and affect the interpretation of the results.

Conclusion

With the results of this study, which was evaluated on a limited number of patients, it may be said that HFNC seems effective and reliable in addressing dyspnea and retraction findings associated with increased workload. It produces earlier and faster clinical improvement measured by RCS than S in infants presenting with the first episode of acute bronchiolitis with moderate to severe clinical severity. It reduces return visits

to PED related to the same disease. However, it seems to be disadvantageous in terms of longer hospital stay. There is a need for studies with large-scale groups regarding the shortening of hospital stay, trials on faster weaning protocols, and/or the applicability of HFNC treatment at home.

Ethics

Ethics Committee Approval: This study was performed in line with the principles of the Declaration of Helsinki. Also, the study was approved by the Local Clinical Researches Ethics Committee of Akdeniz University (15.11.2017-674).

Informed Consent: Informed written consent was obtained from a parent of each child.

Acknowledgments

The authors would like to thank the Physicians and Nurses from the Paediatric Emergency Department of the Akdeniz University Medical Faculty Hospital in Antalya.

Footnotes

Authorship Contributions

Surgical and Medical Practices: Ş.Z.G.D., Ö.T.K., N.E., Ö.B., R.G., Concept: Ö.T.K., N.E., Design: Ö.T.K., N.E., Data Collection or Processing: Ş.Z.G.D., Ö.T.K., N.E., Ö.B., R.G., Analysis or Interpretation: Ş.Z.G.D., Ö.T.K., N.E., Ö.B., R.G., Literature Search: Ş.Z.G.D., Ö.T.K., N.E., Writing: Ö.T.K., N.E.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: This study was supported the Scientific Research Projects of Akdeniz University (TTU-2018-2959).

References

1. American Academy of Pediatrics Subcommittee on diagnosis and management of bronchiolitis. Diagnosis and management of bronchiolitis. *Pediatrics*. 2006;118:1774-93.
2. Pişkin IE, Erkek Atay N, Karacan CD, İpek MS, Yöney A. Current approaches of paediatricians in Turkey to acute bronchiolitis. *Journal of Paediatrics*. 2007;50:168-73. Turkish.
3. Carande EJ, Galiza EP, Nickless A, Pollard AJ, Drysdale SB. Viral bronchiolitis management in hospitals in the UK. *J Clin Virol*. 2018;104:29-33.
4. Dalziel SR, Haskell L, O'Brien S, Borland ML, Plint AC, et al. Bronchiolitis. *The Lancet*. 2022;400:392-406.
5. Mayfield S, Jauncey-Cooke J, Hough JL, Schibler A, Gibbons K, et al. High-flow nasal cannula therapy for respiratory support in children. *Cochrane Database Syst Rev*. 2014;2014:CD009850.
6. Pham TM, O'Malley L, Mayfield S, Martin S, Schibler A. The effect of high flow nasal cannula therapy on the work of breathing in infants with bronchiolitis. *Pediatr Pulmonol*. 2015;50:713-20.
7. Söğütlü Y, Biçer S, Kurt G, Şah G, Şah O, et al. Outcomes of high-flow nasal cannula oxygenation treatment on the vital signs of children with lower respiratory tract diseases. *J Pediatr Emerg Intensive Care Med*. 2016;3:121-30.

8. Ramnarayan P, Lister P, Dominguez T, Habibi P, Edmonds N, et al. FIRST-line support for assistance in breathing in children (FIRST-ABC): protocol for a multicentre randomised feasibility trial of non-invasive respiratory support in critically ill children. *BMJ Open*. 2017;7:e016181.
9. Jamal A, Finkelstein Y, Kuppermann N, Freedman SB, Florin TA, et al. Pharmacotherapy in bronchiolitis at discharge from emergency departments within the Pediatric Emergency Research Networks: a retrospective analysis. *Lancet Child Adolesc Health*. 2019;3:539-47.
10. Lirette MP, Kuppermann N, Finkelstein Y, Zemek R, Plint AC, et al. International variation in evidence-based emergency department management of bronchiolitis: a retrospective cohort study. *BMJ Open*. 2022;12:e059784.
11. Liu LL, Gallaher MM, Davis RL, Rutter CM, Lewis TC, et al. Use of a respiratory clinical score among different providers. *Pediatr Pulmonol*. 2004;37:243-8.
12. McCallum GB, Morris PS, Wilson CC, Versteegh LA, Ward LM, et al. Severity scoring systems: are they internally valid, reliable and predictive of oxygen use in children with acute bronchiolitis? *Pediatr Pulmonol*. 2013;48:797-803.
13. Destino L, Weisgerber MC, Soung P, Bakalarski D, Yan K, et al. Validity of respiratory scores in bronchiolitis. *Hosp Pediatr*. 2012;2:202-9.
14. Carnevale FA, Razack S. An item analysis of the COMFORT scale in a pediatric intensive care unit. *Pediatr Crit Care Med*. 2002;3:177-80.
15. Ambuel B, Hamlett KW, Marx CM, Blumer JL. Assessing distress in pediatric intensive care environments: the COMFORT scale. *J Pediatr Psychol*. 1992;17:95-109.
16. Spentzas T, Minarik M, Patters AB, Vinson B, Stidham G. Children with respiratory distress treated with high-flow nasal cannula. *J Intensive Care Med*. 2009;24:323-8.
17. Rodriguez H, Hartert TV, Gebretsadik T, Carroll KN, Larkin EK. A simple respiratory severity score that may be used in evaluation of acute respiratory infection. *BMC Res Notes*. 2016;9:85.
18. Fleming S, Thompson M, Stevens R, Heneghan C, Plüddemann A, et al. Normal ranges of heart rate and respiratory rate in children from birth to 18 years of age: a systematic review of observational studies. *Lancet*. 2011;377:1011-8.
19. Davison M, Watson M, Wockner L, Kinnear F. Paediatric high-flow nasal cannula therapy in children with bronchiolitis: A retrospective safety and efficacy study in a non-tertiary environment. *Emerg Med Australas*. 2017;29:198-20.
20. Er A, Çağlar A, Akgül F, Ulusoy E, Çitlenbik H, et al. Early predictors of unresponsiveness to high-flow nasal cannula therapy in a pediatric emergency department. *Pediatr Pulmonol*. 2018;53:809-15.
21. Heikkilä P, Sokuri P, Mecklin M, Nuolivirta K, Tapiainen T, et al. Using high-flow nasal cannulas for infants with bronchiolitis admitted to paediatric wards is safe and feasible. *Acta Paediatr*. 2018;107:1971-6.
22. Franklin D, Babl FE, Schlapbach LJ, Oakley E, Craig S, et al. A randomized trial of high-flow oxygen therapy in infants with bronchiolitis. *N Engl J Med*. 2018;378:1121-31.
23. Türe E, Yazar A, Akın F, Pekcan S. High-flow nasal cannula is superior to standard face-mask oxygen therapy in viral bronchiolitis. *Signa Vitae*. 2020;16:47-53.
24. Yurtseven A, Saz EU, Hennes H. Safety and efficacy of high-flow nasal cannula therapy in the pediatric emergency department. *J Pediatr Emerg Intensive Care Med*. 2019;6:121-9.
25. Aydın O, Arslanoğlu Aydın E, Birbilen AZ, Tekşam O. Predictive factors of high-flow nasal cannula oxygen therapy failure in children with respiratory distress treated in a Paediatric Emergency Department. *Turk J Pediatr*. 2021;63:1012-9.
26. Shay DK, Holman RC, Newman RD, Liu LL, Stout JW, Anderson LJ. Bronchiolitis-associated hospitalizations among US children, 1980-1996. *JAMA*. 1999;282:1440-6.
27. Mansbach JM, Piedra PA, Teach SJ, Sullivan Af, Forgey T, et al. Prospective multicenter study of viral etiology and hospital length of stay in children with severe bronchiolitis. *Arch Pediatr Adolesc Med*. 2012;166:700-6.
28. Jartti T, Aakula M, Mansbach JM, Piedra PA, Bergroth E, et al. Hospital length-of-stay is associated with rhinovirus etiology of bronchiolitis. *Pediatr Infect Dis J*. 2014;33:829-34.
29. Franklin D, Babl FE, George S, Oakley E, Borland ML, et al. Effect of early high-flow nasal oxygen vs standard oxygen therapy on length of hospital stay in hospitalized children with acute hypoxemic respiratory failure: the PARIS-2 randomized clinical trial. *JAMA*. 2023;329:224-34.
30. Storgaard LH, Hockey HU, Weinreich UM. Development in PaCO₂ over 12 months in patients with COPD with persistent hypercapnic respiratory failure treated with high-flow nasal cannula-post-hoc analysis from a randomised controlled trial. *BMJ Open Respir Res*. 2020;7:e000712.
31. Joseph L, Goldberg S, Shitrit M, Picard E. High-flow nasal cannula therapy for obstructive sleep apnea in children. *J Clin Sleep Med*. 2015;11:1007-10.
32. Hawkins S, Huston S, Campbell K, Halbower A. High-flow, heated, humidified air via nasal cannula treats CPAP-intolerant children with obstructive sleep apnea. *J Clin Sleep Med*. 2017;13:981-9.
33. Alibrahim O, Esquinas A. Home HFNC in children with heart disease: is it safe? *Pediatr Cardiol*. 2022;43:931.
34. Muneuchi J, Sugitani Y, Watanabe M. The safety of home high-flow nasal cannula therapy in children with congenital heart disease and miscellaneous respiratory problems. *Pediatr Cardiol*. 2022;43:930.
35. Ehrlich S, Tripto IG, Lavie M, Cahal M, Shonfeld T, et al. High flow nasal cannula therapy in the paediatric home setting. *Paediatr Pulmonol*. 2023;58:941-8.
36. Hutchings FA, Hilliard TN, Davis PJ. Heated humidified high-flow nasal cannula therapy in children. *Arch Dis Child*. 2015;100:571-5.
37. Betters KA, Hebbar KB, McCracken C, Heitz D, Sparacino S, et al. A novel weaning protocol for high-flow nasal cannula in the PICU. *Pediatr Crit Care Med*. 2017;18:e274-80.
38. Franklin D, Dalziel S, Schlapbach LJ, Babl FE, Oakley E, et al. Early high flow nasal cannula therapy in bronchiolitis, a prospective randomised control trial (protocol): a paediatric acute respiratory intervention study (PARIS). *BMC Pediatrics*. 2015;15:183.
39. Swingler GH, Hussey GD, Zwarenstein M. Duration of illness in ambulatory children diagnosed with bronchiolitis. *Arch Pediatr Adolesc Med*. 2000;154:997-1000.
40. Kemper AR, Kennedy EJ, Dechert RE, Saint S. Hospital readmission for bronchiolitis. *Clin Pediatr*. 2005;44:509-13.
41. Norwood A, Mansbach JM, Clark S, Waseem M, Camargo CA Jr. Prospective multicenter study of bronchiolitis: predictors of an unscheduled visit after discharge from the emergency department. *Acad Emerg Med*. 2010;17:376-82.

42. Uysalol M, Haşlak F, Özünal ZG, Vehid H, Uzel N. Rational drug use for acute bronchiolitis in emergency care. *Turk J Pediatr.* 2017;59:155-61.
43. Burns JJ, Evans R, Pham C, Nayak W, Amin R. Risk factors predicting readmission to the hospital in children with bronchiolitis. *Clin Pediatr (Phila).* 2018;57:1699-702.
44. Kook Y, Lee JS, Ryu JM. Risk factors for acute bronchiolitis-related return visits to the emergency department. *PEMJ.* 2021;8:95-9.
45. Schroeder AR, Destino LA, Vukin E, Brooks R, Stoddard G, et al. Day of illness and outcomes in bronchiolitis hospitalisations. *Pediatrics.* 2020;146:e20201537.
46. Valencia-Ramos J, Ochoa Sangrador C, García M, Oyagüez P, Arnaez J. Impact of different nebulisation systems on patient comfort in bronchiolitis: a randomised controlled cross-over trial. *Arch Dis Child.* 2022;107:1122-7.



Quantitative Measurement of Lung Radiodensity on Chest X-ray Improves Diagnosis of Foreign Body Aspirations in Children

Direkt Akciğer Grafisinde Akciğer Radyodansitesinin Kantitatif Ölçümü Çocuklarda Yabancı Cisim Aspirasyonlarının Tanısını İyileştirir

© Ayten Bilen¹, © Fatma Ceren Sarıoğlu², © Efil Aydın¹, © Serra Sabuncu¹, © Osman Zeki Karakuş¹, © Oktay Ulusoy¹, © Handan Gülyüz², © Oğuz Ateş¹, © Gülce Hakküder¹, © Mustafa Olguner¹, © Miraç Feza Akgür¹

¹Dokuz Eylül University Faculty of Medicine, Department of Pediatric Surgery, İzmir, Türkiye

²Dokuz Eylül University Faculty of Medicine, Department of Radiology, Division of Pediatric Radiology, İzmir, Türkiye

Abstract

Introduction: Chest X-ray (CXR) is the primary imaging method for the diagnosis of foreign body (FB) aspiration (FBA) and the most common finding is ipsilateral hyperinflation due to air-trapping. FB related hyperinflation can be subtle and difficult to detect in the evaluation of the CXR. Radiodensity measurement of the lungs on CXR could be useful for the diagnosis of FBA. The aim of this study is to evaluate the diagnostic effectiveness of quantitative measurement of lung radiodensity in detecting hyperinflation on CXR of the patients with suspected FBA.

Methods: Records of patients who underwent rigid bronchoscopy for evaluation of FBA between January 2008 and June 2020 were reviewed retrospectively. Initial CXR of the patients were re-evaluated quantitatively by measuring lung radiodensity in FBA present and FBA absent groups.

Results: FB was detected in 154 patients, while FB was not detected in 87 patients during bronchoscopy. FB was in right lung in 89 patients, in left lung in 51 patients thus unilateral FB was present in 140 patients. Records of initial CXR evaluation of these 140 patients with unilateral FB showed unilateral lung hyperinflation in 60 patients (42.9%) and no unilateral hyperinflation in 80 patients (57.1%). Lung radiodensities of the FB-present lungs were statistically significantly less dense compared with radiodensities of the contralateral lungs. A 5.5% or more lung radiodensity difference compatible with hyperinflation were found in 113 out of 140 patients (80.7%) with unilateral FB during lung radiodensity measurements. During the initial CXR evaluation, the hyperinflation detection rate was 42.9%, with the lung radiodensity measurement, the hyperinflation detection rate increased to 80.7%

Öz

Giriş: Direkt akciğer grafisi (PA-AC grafisi), yabancı cisim aspirasyonu (YCA) tanısında birincil görüntüleme yöntemidir ve en yaygın bulgu hava yolu tıkanıklığına bağlı gelişen ipsilateral havalanma artışıdır. Yabancı cisim (YC) ile ilişkili havalanma artışının PA-AC grafisi ile değerlendirilmesi her zaman kolay olmayabilir. Akciğerlerin, PA-AC grafisi üzerindeki radyodansitelerinin ölçülmesi, YCA tanısı için yararlı olabilir. Bu çalışmanın amacı, şüpheli YCA olgularında PA-AC grafisinde havalanma artışının tespitinde akciğer radyodansitesinin kantitatif ölçümünün tanılabilirliğini değerlendirmektir.

Yöntemler: Ocak 2008 ile Haziran 2020 tarihleri arasında YCA nedeniyle rijit bronkoskopi yapılan hastaların kayıtları geriye dönük olarak incelendi. YCA olan ve olmayan gruplarda akciğer radyodansitesi ölçülerek hastaların başlangıç PA-AC grafileri yeniden değerlendirildi.

Bulgular: Yüz elli dört hastada rijit bronkoskopi sonucunda yabancı cisim tespit edilirken, 87 hastada tespit edilmedi. Tek taraflı yabancı cisim tespit edilen 140 hastanın 89'unda yabancı cisim sağda, 51 hastada ise solda idi. Tek taraflı yabancı cisim saptanan hastaların PA-AC grafileri retrospektif olarak değerlendirildiğinde, 60 hastada (%42,9) tek taraflı havalanma artışı tespit edilirken, 80 hastada (%57,1) PA-AC grafisinde havalanma artışı izlenmemiştir. Akciğer grafileri radyodansite ölçümü ile değerlendirildiğinde yabancı cisim bulunan akciğerlerin radyodansiteleri, karşı akciğer radyodansitelerine göre istatistiksel olarak anlamlı derecede daha az yoğundu. Rijit bronkoskopi ile tek taraflı yabancı cisim tespit edilen 140 hastanın 113'ünde (%80,7) akciğer radyodansitesi ölçümleri sırasında tek taraflı hava hapsi ile uyumlu en az %5,5'lik bir akciğer radyodansitesi farkı bulundu. Başlangıç PA-AC grafisi değerlendirilmesi ile radyodansite ölçümü sonrası yapılan

Address for Correspondence/Yazışma Adresi: ssoc. Prof. Oktay Ulusoy, Dokuz Eylül University Faculty of Medicine, Department of Pediatric Surgery, İzmir, Türkiye

E-mail: oktay.ulusoy@deu.edu.tr **ORCID ID:** orcid.org/0000-0002-0992-8724

Received/Geliş Tarihi: 27.06.2024 **Accepted/Kabul Tarihi:** 01.10.2024 **Epub:** 08.10.2025 **Publication Date/Yayınlanma Tarihi:** 01.04.2026

Cite this article as: Bilen A, Sarıoğlu FC, Aydın E, Sabuncu S, Karakuş OZ. et al. Quantitative measurement of lung radiodensity on chest X-ray improves diagnosis of foreign body aspirations in children. J Pediatr Emerg Intensive Care Med. 2026;13(1):13-7



Abstract

Conclusion: Quantitative lung radiodensity measurement of CXR in patients with suspected FB aspiration could increase the efficiency of FB related hyperinflation detection.

Keywords: Chest X-ray, foreign body aspiration, radiodensity measurement

Öz

değerlendirmenin karşılaştırılmasında hava hapsinin tespit oranının %42,9'dan %80,7'ye yükseldiği görüldü.

Sonuç: Şüpheli YCA hastalarında PA-AC grafisi üzerindeki radyodansitenin kantitatif ölçülmesi, yabancı cisimle ilişkili hava hapsinin tespitini ve PA-AC grafisi tanısıl etkinliğini artırabilir.

Anahtar Kelimeler: PA-AC grafisi, yabancı cisim aspirasyonu, radyodansite ölçümü

Introduction

Foreign body aspiration (FBA) is associated with morbidity and mortality related to diagnostic delay during childhood.¹ Delayed or missed diagnosis of FBA causes long-term complications, such as pneumonia, bronchiectasis, and atelectasis.^{2,3} Diagnosis and early removal of the foreign body (FB) are vital for reducing potential complications and mortality.^{4,5} Bronchoscopy is the gold standard for the diagnosis and treatment of FBA.^{6,7}

Chest X-ray (CXR) is the primary and frequently used imaging modality for diagnosing FBA. The most common finding in CXR is ipsilateral hyperinflation due to air-trapping (34-71%).⁸⁻¹⁰ FB-related hyperinflation can be subtle and difficult to detect during CXR evaluation. Radiodensity measurements of the lungs using CXR can be useful for diagnosing FBA.^{10,11} This study aimed to evaluate the diagnostic effectiveness of quantitative lung radiodensity measurement for detecting hyperinflation on CXR in patients with suspected FBA.

Materials and Methods

Study Design and Population

The Institutional Clinical Research Ethics Review Board Dokuz Eylül University approved this study (approval no: GOA-5781, 2021/03-56, date: 01.02.2021). The records of patients who underwent rigid bronchoscopy for FBA evaluation between January 2008 and June 2020 were retrospectively reviewed. The reviewed parameters were age, sex, presenting symptoms, duration of symptoms, records of initial CXR findings, anatomic location of the FB as detected during bronchoscopy, complications, and length of hospital stay. Initial CXRs of patients were re-evaluated quantitatively by measuring lung radiodensity. Two groups were formed in the study.

1- FB-present group: This group comprised patients who underwent rigid bronchoscopy with suspected FBA and FB.

2- FB-absent group: Patients who underwent rigid bronchoscopy with suspected FBA but without FB detection.

Study Setting

(Radiographic density measurement of a CXR), posterior-anterior CXRs were obtained using M-Cabinet CXA (Phillips Medical System, Hamburg, Germany) and evaluated using Sectra Systems (Sectra Myrian, Expert 2.0/0502). Examination parameters were 6-8 mA, and 60-75 kV, depending on the patient's age and weight. Digital data from CXR were sent to a picture-archiving and communication system (PACS; Sectra, İzmir, Türkiye). For quantitative assessment, a radiodensity calculation system was used to measure the mean density on CXR. The radiologists worked blindly without knowing the bronchoscopy results during the radiodensity measurement on CXR. Radiodensity measurements were made using region of interest (ROI) drawings: ROIs for the entire right or left lung were drawn. The margin of the lung was delimited by the rib cage, cardiac border, and diaphragm (Figure 1).

Statistical Analysis

Data were analyzed using SPSS software for Windows version 22 (SPSS, Chicago, IL, USA). The compliance of the data to normal distribution was examined by visual (histograms and

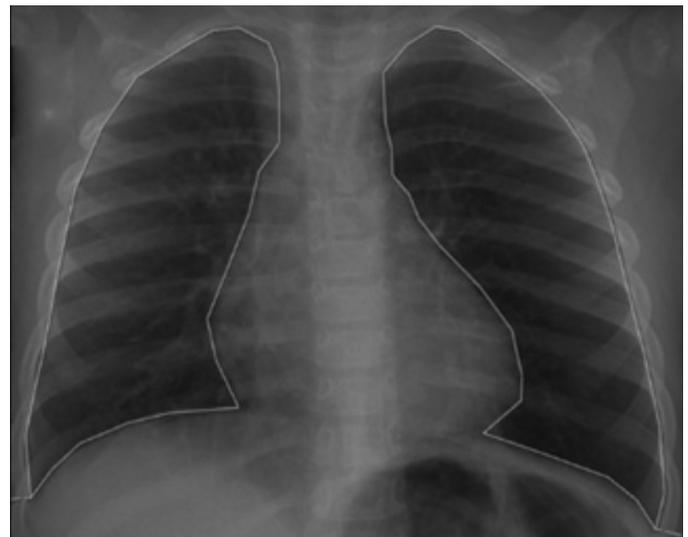


Figure 1. Chest X-ray showing lung regions of interest. The lung margin is delimited by the rib cage, cardiac border, and diaphragm

graphs) and analytical (Kolmogorov-Smirnov/Shapiro-Wilk tests). Because the data did not conform to the normal distribution, the parameters between the groups were evaluated by Kruskal-Wallis variance analysis. In cases of significant differences between groups, the Mann-Whitney U test was used for post-hoc pairwise comparisons. The statistical significance level was set as $p < 0.05$.

Results

In total, 241 patients were hospitalized with a preliminary diagnosis of FBA. The female to male ratio was 93/148 (38.6/61.4%). The mean patient age was 30.6 ± 1.6 months (range, 1-160 months).

The histories of 162 patients suggested FBA, 54 patients did not suggest FBA, and 25 patients' histories were inconclusive. Among these, 159 patients had a history of cough, 55 had a history of choking, 85 had wheezing, 60 had bruising, 36 had fever, and 31 had a history of chronic lower respiratory tract infection. The mean time from symptom onset to presentation to the emergency department was $178.423.1 \pm$ hours (range, 24-1440 hours) (median 24 hours).

Bronchoscopy findings: FB was detected in 154 patients (63.9%) patients, whereas it was not detected in 87 patients (36.1%) during bronchoscopy. The FBs were located in the right lung in 89 patients, in the left lung in 51 patients, in both lungs in 5 patients, and in the trachea in 9 patients. Overall, 140 patients presented with unilateral FB. Average bronchoscopy conduction time averaged 10.9 ± 0.4 minutes (range, 5-60 minutes). Nine patients (3.7%) required reintubation and intensive care monitoring after bronchoscopy due to airway edema and difficulty in spontaneous breathing. In 4

patients, bronchoscopy was repeated because the FB could not be removed completely during the first bronchoscopy. Thoracotomy was performed in three patients (1.2%) because the FB could not be removed during bronchoscopy. There is no mortality in our study.

Radiological evaluation: A unilateral bronchoscopy-proven FB was present in 140 patients. Records of the initial CXR evaluation showed hyperinflation on the right side in 37 patients and on the left side in 23 patients. Records of the initial CXR evaluation showed unilateral lung hyperinflation in 60 patients (42.9%) and no unilateral hyperinflation in 80 patients (57.1%) (Table 1). Hyperdense FB was detected in the right lung in 5 patients and the left lung in 1 patient.

Lung radiodensity measurements are presented in Table 2. The lung radiosensitizes of the FBs (ipsilateral lungs) were significantly less dense than the radiosensitizes of the contralateral lungs. The lung radiosensitizes of the FB-absent groups in both lungs were not significantly different. When the raw lung radiodensity measurements were analyzed individually, lungs with FB were 5.5% to 21.7% denser than contralateral lungs in patients with FB.

Contralateral lung FB-related hyperinflation detection rates during the initial CXR assessment and after lung radiodensity measurement are presented in Table 1. Of the 140 patients with unilateral FB, while hyperinflation was detected in 60 patients (42.9%), hyperinflation was not detected in 80 out of 140 patients (57.1%) during the initial CXR evaluation. However, 5.5% or more lung radiodensity differences compatible with hyperinflation were found in 113 out of 140 patients (80.7%) during lung radiodensity measurements (Table 1). During the initial CXR evaluation, the hyperinflation detection rate was

Table 1. Contralateral lung hyperinflation detection rates with initial CXR assessment versus quantitative radiodensity measurement (patients with bilateral and tracheal foreign bodies were excluded)

| | Initial CXR assessment (n=140) | | Lung radiodensity measurement* (n=140) | |
|-----------------------|--------------------------------|--------------------------|--|--------------------------|
| | Hyperinflation (+) n (%) | Hyperinflation (-) n (%) | Hyperinflation (+) n (%) | Hyperinflation (-) n (%) |
| FB in right lung n=89 | 37 (41.5%) | 52 (58.5%) | 74 (83.1%) | 15 (16.9%) |
| FB in left lung n=51 | 23 (45.1%) | 28 (54.9%) | 39 (76.5%) | 12 (23.5%) |
| Total | 60 (42.9%) | 80 (57.1%) | 113 (80.7%) | 27 (19.3%) |

*: 5.5% or more lung radiodensity difference between ipsilateral and contralateral lung was defined as presence of foreign body related hyperinflation, CXR: Chest X-ray, FB: Foreign body

Table 2. Lung radiodensity measurements of CXR (mean \pm SEM)

| | FB-present in right lung (n=89) | FB-present in left lung (n=51) | FB-absent group (n=87) |
|------------|---------------------------------|--------------------------------|------------------------|
| Right lung | 979.5 \pm 60.1* | 1076.8 \pm 63.6 | 1141.0 \pm 82.0 |
| Left lung | 1096.5 \pm 69.8 | 928.4 \pm 66.8* | 1158.5 \pm 82.7 |

*: $p < 0.01$ compared with contralateral lung, CXR: Chest X-ray, FB: Foreign body, SEM: Standard error of the mean

42.9%, and the lung radiodensity measurement revealed that the hyperinflation detection rate increased to 80.7% (Table 1).

Evident right hyperinflation on the CXR is shown in Figure 2A. The CXR of the patient with FB in whom no hyperinflation was detected in the initial CXR evaluation showed a 6.4% density difference compatible with hyperinflation detected in the lung radiodensity measurement of the CXR (Figure 2B).

On the other hand, the initial CXR findings of the five patients were not consistent with bronchoscopy findings. Although hyperinflation was detected on the left side in three patients and on the right side in two patients, FB was found on the contralateral side during bronchoscopy. However, CXR lung radiodensity measurements were consistent with bronchoscopy findings.

Postoperative management: In the postoperative period, 66 patients received nebulized salbutamol, 23 received nebulized budesonide, and 20 received nebulized adrenaline due to airway reactivity and dyspnea. In the postoperative period, 19 patients required 4-6 L/min O₂, and cold steam was applied to 40 patients. The length of hospital stay was 42.72.6± hours (range 7-96 hours) (median 41 hours).

Discussion

FBA is a preventable emergency pathology in childhood. Delayed diagnosis of FBA is associated with the risk of pneumonia, pneumothorax, respiratory failure, and mortality.³ In a series of 11,000 pediatric patients with FBA, the overall mortality risk was 2.5%.³ Bronchoscopy is the most effective method for the diagnosis and treatment of FBA.^{6,7} The prognostic results of bronchoscopy are encouraging when FBs are removed properly. Therefore, an early diagnosis of FB

and immediate intervention is important for the successful treatment of FBA.^{5,12}

A significant history of FB is an indication for bronchoscopy alone.⁹ In the present series, the major symptoms were cough (65.9%), choking (22.8%), and wheezing (35.3%). The sensitivity and specificity of symptoms at diagnosis were 75.3% and 50.6% for cough, 22.1% and 75.8% for choking, and 42.8% and 78.2% for wheezing, respectively.

The rate of negative bronchoscopy in the present study was 36.1%. Therefore, radiological imaging is crucial in patients with suspected FBA to reduce potential complications. CXR is the primary imaging modality for FBA evaluation. The most common finding in CXR after FBA is hyperinflation.⁸⁻¹⁵ The determination of lung radiodensity is a quantitative measurement method that can be used during CXR evaluation.^{10,11} Decreased ipsilateral lung radiodensity due to unilateral hyperinflation is a typical radiological finding in FBA.^{10,11} Calculating the radiodensity ratio of both lungs in CXR is useful for the diagnosis of FBA.^{10,11} Song et al.¹⁰ measured CXR lung radiosensitizes in 22 children with bronchoscopy-proven unilateral FB and compared the radiodensities before and after bronchoscopic FB removal. Song et al.¹⁰ found that the CXR radiodensity of the ipsilateral lung was lower than that of the contralateral lung and significantly increased after bronchoscopic FB removal. Caliskan et al.¹¹ measured CXR lung radiosensitizes in 33 children with bronchoscopy-proven unilateral FB and found that the presence of unilateral FB decreased the lung radiodensity of the ipsilateral lung. The present series is the largest in the literature, comprising 140 patients with bronchoscopy-proven unilateral FB. The current study is the first study to compare the hyperinflation detection rate during initial CXR assessment with the hyperinflation

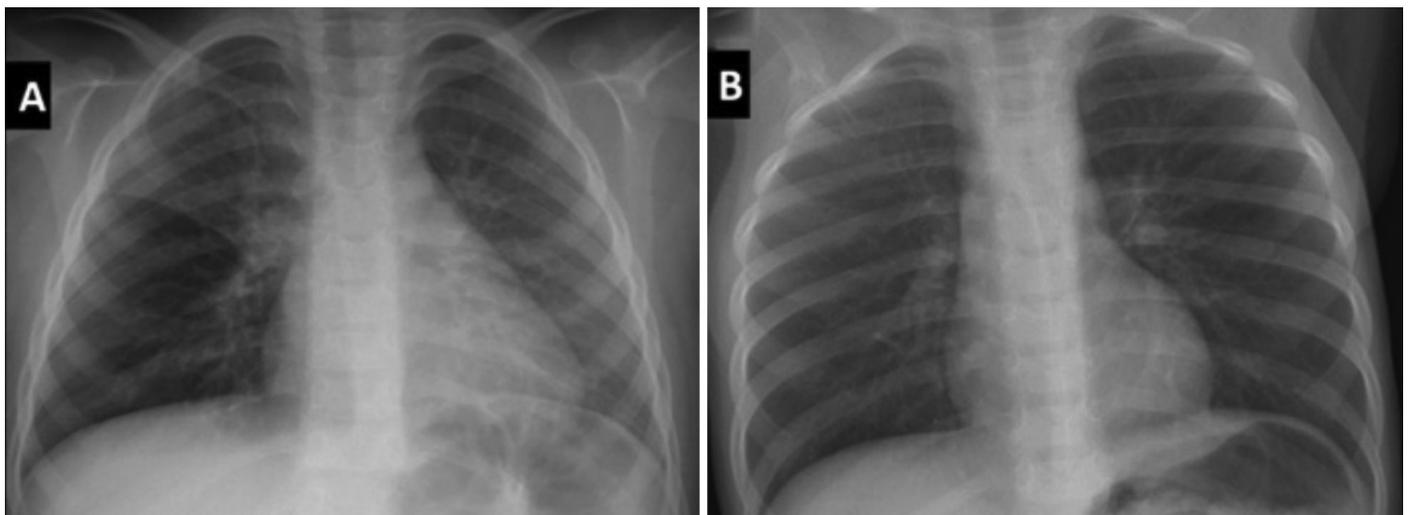


Figure 2. A) Evident right middle and lower lobe hyperinflation on the CXR of a 6-year-old boy, B) Normal CXR appearance without evident hyperinflation in a 7-year-old boy. Lung radiodensity measurements of this patient showed 6.4% less left lung radiodensity, indicating hyperinflation

CXR: Chest X-ray

detection rate during CXR lung radiodensity measurement. This study showed that quantitative evaluation of CXR through lung radiodensity measurement increased the detection rate of FB-related hyperinflation from 42.9% to 80.7%. We believe that quantitative measurement of lung radiodensity in patients with suspected FBA could decrease the misinterpretation rate of CXR due to individual or technical reasons.

Conclusion

We conclude that quantitative lung radiodensity measurement on CXR in patients with suspected FBA may increase the efficiency of FB-related hyperinflation detection.

Ethics

Ethics Committee Approval: The Institutional Clinical Research Ethics Review Board Dokuz Eylül University approved this study (approval no: GOA-5781, 2021/03-56, date: 01.02.2021).

Informed Consent: Retrospective study.

Footnotes

Authorship Contributions

Surgical and Medical Practices: A.B., E.A., S.S., O.Z.K., O.U., O.A., G.H., M.O., M.F.A., Concept: A.B., O.Z.K., Design: A.B., O.Z.K., Data Collection or Processing: A.B., F.C.S., E.A., S.S., O.Z.K., O.U., H.G., Analysis or Interpretation: A.B., F.C.S., O.Z.K., Literature Search: A.B., O.Z.K., Writing: A.B., O.Z.K., O.U., O.A., G.H., M.O., M.F.A.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

References

1. Metrangolo S, Monetti C, Meneghini L, Zadra N, Giusti F. Eight years' experience with foreign-body aspiration in children: what is really important for a timely diagnosis? *J Pediatr Surg.* 1999;34:1229-31.
2. Ciftci AO, Bingöl-Koçulu M, Şenocak ME, Tanyel FC, Büyükpamukçu N. Bronchoscopy for evaluation of foreign body aspiration in children. *J Pediatr Surg.* 2003;38:1170-6.
3. Johnson K, Linnaus M, Notrica D. Airway foreign bodies in pediatric patients: anatomic location of foreign body affects complications and outcomes. *Pediatr Surg Int.* 2017;33:59-64.
4. Li P, Jiang G, Li Q. The risks of postoperative complications and prolonged hospital stay in children receiving bronchoscopy. *J Pediatr Surg.* 2020;55:1309-12.
5. Li Y, Wu W, Yang X, Li J. Treatment of 38 cases of foreign body aspiration in children causing life-threatening complications. *Int J Pediatr Otorhinolaryngol.* 2009;73:1624-9.
6. Paradis TJ, Dixon J, Tieu BH. The role of bronchoscopy in the diagnosis of airway disease. *J Thorac Dis.* 2016;8:3826-37.
7. Ozdemir S, Surmelioglu O, Tarkan O, Tuncer U, Kiroglu M, et al. The utility of endoscope-assisted rigid bronchoscopy in pediatric airway foreign body removals. *J Craniofac Surg.* 2020;31:e217-9.
8. Boufersaoui A, Smati L, Benhalla KN, Boukari R, Smail S, et al. foreign body aspiration in children: experience from 2624 patients. *Int J Pediatr Otorhinolaryngol.* 2013;77:1683-8.
9. Halwai O. A study of clinical presentations and complications of foreign body in the bronchus-our experience. *Otolaryngol Pol.* 2015;69:22-8.
10. Song ES, Han DK, Cho HJ, Jeong IS, Yoon N, et al. Radiodensity on serial chest X-rays for the diagnosis of foreign body aspiration in children. *Indian Pediatr.* 2015;52:663-7.
11. Caliskan E, Aliyev S, Habibi HA, Bayramoglu Z, Yilmaz R, et al. Utility of lung radiodensity ratios in diagnosis of radiolucent foreign body aspiration in children: a practical approach. *Clin Imaging.* 2019;54:178-82.
12. Wang G, Pan Z, Li H, Li Y, Dai J, et al. Diagnosis and treatment of tracheobronchial foreign bodies in 1024 children. *J Pediatr Surg.* 2012;47:2004-10.
13. Gibbons AT, Casar Berazaluze AM, Hanke RE, McNinch NL, Person A, et al. Avoiding unnecessary bronchoscopy in children with suspected foreign body aspiration using computed tomography. *J Pediatr Surg.* 2020;55:176-81.
14. Kiyani G, Gocmen B, Tugtepe H, Karakoc F, Dagli E, et al. Foreign body aspiration in children: the value of diagnostic criteria. *Int J Pediatr Otorhinolaryngol.* 2009;73:963-7.
15. Friedman EM, Anthony B. A five-year analysis of airway foreign body management: toward a better understanding of negative bronchoscopies. *Ann Otol Rhinol Laryngol.* 2016;125:591-5.



Risk Factors in Cardiovascular Surgery in Down Syndrome Patients: Single-center Experience

Down Sendromlu Hastalarda Kardiyovasküler Cerrahide Risk Faktörleri: Tek Merkez Deneyimi

© Sinan Yavuz¹, © Umut Berk Mercan¹, © Selman Kesici¹, © Ahmet Aydın², © Hayrettin Hakan Aykan¹, © Mustafa Yılmaz², © Benan Bayrakçı¹

¹Hacettepe University Faculty of Medicine, Department of Pediatrics, Ankara, Türkiye

²Hacettepe University Faculty of Medicine, Department of Cardiovascular Surgery, Ankara, Türkiye

Abstract

Introduction: The aim of this study was to determine the surgical risks in patients with Down syndrome (DS) and cardiac pathology. We aim to share our single-center experience and identify risk factors among patients with DS undergoing cardiac surgery. Patients under the age of 18 who underwent cardiac surgery at Hacettepe University between 1996 and 2019 were included.

Methods: This retrospective cohort study included all pediatric patients with DS who underwent surgery for congenital heart disease (CHD).

Results: A total of 175 patients were included in the study. Seventy-five patients (42.8%) were male and the median age of the patients was 7 months (1-86 months). The most common cardiac pathology was atrial septal defect (19.2%), followed by atrioventricular septal defect (18.7%) and ventricular septal defect (11.3%). According to the risk adjustment for congenital heart surgery classification, most patients were in category 2 (41.7%) and category 3 (42.3%). Sixty-one patients (34.9%) were diagnosed with systemic inflammatory response syndrome (SIRS) in the postoperative period. Seven patients (3.4%) needed extracorporeal membrane oxygenation. Overall mortality was 30.3%.

Conclusion: This single-center study characterized the pattern of CHD in a specific cohort of patients with DS and identified risk factors associated with cardiac surgery. Postoperative SIRS and high-risk surgical procedures were associated with an increased risk of mortality.

Keywords: Cardiac surgery, Down syndrome, risk factors

Öz

Giriş: Down sendromlu (DS) ve kardiyak patolojisi olan hastaların cerrahi risklerinin belirlenmesi amaçlanmıştır. Amacımız, tek bir merkezden deneyimlerimizi paylaşmak ve kardiyak cerrahi geçiren DS'li hastalarda risk faktörlerini belirlemektir. 1996-2019 yılları arasında Hacettepe Üniversitesi'nde kardiyak cerrahi geçiren 18 yaş altı hastalar incelenmiştir.

Yöntemler: Bu geriye dönük kohort çalışması, konjenital kalp hastalığı (KKH) cerrahisi geçiren tüm pediyatrik DS'li hastaları içermektedir.

Bulgular: Çalışmaya 175 hasta dahil edildi. Yetmiş beş hasta (%42,8) erkekti ve hastaların ortanca yaşı 7 aydı (1-86 ay). En sık görülen kardiyak patoloji atriyal septal defekt (%19,2), ardından atrioventriküler septal defekt (%18,7) ve ventriküler septal defekt (%11,3) idi. Doğuştan kalp cerrahisi için risk ayarlaması kalp cerrahisi sınıflandırmasına göre, hastaların çoğu kategori 2 (%41,7) ve kategori 3 (%42,3) idi. Altmış bir hastaya (%34,9) ameliyat sonrası dönemde sistemik enflamatuvar yanıt sendromu (SIRS) tanısı konuldu. Yedi hastada (%3,4) ekstrakorporeal membran oksijenasyonuna ihtiyaç duyuldu. Genel mortalite oranı %30,3 idi.

Sonuç: Tek bir merkezde yürütülen bu çalışma, DS'li belirli bir hasta grubunda KKH örüntüsünü ve kalp cerrahisiyle ilişkili risk faktörlerini ortaya koydu. Ameliyat sonrası SIRS ve yüksek riskli cerrahi prosedürlerin artan mortalite riskiyle bağlantılı olduğu bulundu.

Anahtar Kelimeler: Kardiyovasküler cerrahi, Down sendromu, risk faktörleri

Address for Correspondence/Yazışma Adresi: Sinan Yavuz, MD, Hacettepe University Faculty of Medicine, Department of Pediatrics, Ankara, Türkiye

E-mail: sinan2438@hotmail.com **ORCID ID:** orcid.org/0000-0001-6159-8710

Received/Geliş Tarihi: 14.06.2025 **Accepted/Kabul Tarihi:** 16.10.2025 **Epub:** 25.02.2026 **Publication Date/Yayınlanma Tarihi:** 01.04.2026

Cite this article as: Yavuz S, Mercan UB, Kesici S, Aydın A, Aykan HH, et al. Risk factors in cardiovascular surgery in Down syndrome patients: single-center experience. J Pediatr Emerg Intensive Care Med. 2026;13(1):18-22



©Copyright 2026 The Author(s). Published by Galenos Publishing House on behalf of Society of Pediatric Emergency and Intensive Care Medicine. This is an open access article under the Creative Commons Attribution-Attribution-NonCommercial 4.0 (CC BY-NC 4.0) International License.

Introduction

Down syndrome (DS) is the most common chromosomal abnormality among live-born infants, and DS is characterized by a variety of dysmorphic features, congenital malformations, and medical conditions.¹ Approximately half of individuals with DS have congenital heart disease (CHD).² In the largest population-based study, cardiovascular abnormalities were detected in 342 (42%) of 821 babies born with DS between 1985 and 2006 in the northeastern region of England.³ Twenty-three percent had more than one abnormality, and the secondary lesion was most commonly an atrial septal defect (ASD) or a patent ductus arteriosus (PDA). Primary lesions were ranked by frequency as follows: endocardial cushion defect (37%), ventricular septal defect (VSD) (31%), ASD (15%), tetralogy of fallot (TOF, 5%), and PDA (4%). Given the risk of mortality and morbidity in postoperative patients, follow-up care is as critical as the surgical procedure itself. The first 24 hours are particularly high risk and require intensive monitoring. Pediatric intensive care units and pediatric cardiac intensive care units (PCICU) play an increasingly essential role in managing these critical periods.⁴

In this study, we aimed to report the experiences of patients with DS who underwent congenital heart surgery at a single-center over 23 years and determine associated risk factors.

Materials and Methods

This study was conducted in the PCICU of Hacettepe University Hospital. All pediatric patients (0-18 years) who underwent open CHD surgery between 1996 and 2019 and were admitted to PCICU were evaluated; those with DS were included in the study. Our pediatric intensive care unit comprises 16 beds and is managed by four pediatric intensivists. The PCICU has six beds and is overseen by six cardiovascular surgeons who rotate on a schedule. Approximately 350 pediatric surgical procedures are performed each year. In our unit, standardized protocols are implemented for the perioperative management of pediatric cardiac surgery patients. Each patient is visited by the intensivist both preoperatively and postoperatively. Following surgery, recommendations are provided regarding mechanical ventilation settings and medical treatments are prescribed as indicated. Patients are visited regularly throughout their intensive care stay, except in emergency situations when immediate intervention is required. Upon transfer from the intensive care unit, follow-up visits are conducted in the ward to ensure continuity of care. Patient data were obtained from the hospital archive. Demographic variables, cardiac pathology, type of surgery, pump times, complications, need for transfusion, laboratory parameters, duration of mechanical ventilation, development of systemic inflammatory response syndrome (SIRS), length of PCICU

stay and hospital stay, additional disease information, and mortality were recorded. The risk adjustment for congenital heart surgery (RACHS-1) score was used to classify surgeries.⁵ Ethical approval for this study was obtained from the Hacettepe University Non-Clinical Research Ethics Committee (approval no: 2019/08-27, date: 19.03.2019). All participants were informed about the study, and written consent was obtained. The study excluded patients with missing data, an uncertain diagnosis of DS, or admission without subsequent surgery.

Statistical Analysis

Descriptive statistics for continuous variables were presented as the mean and standard deviation when the assumption of normality was met, and as the median (minimum-maximum) for non-normal distributions. Moreover, categorical variables were presented with frequencies and percentages. The assumption of normality was assessed using the Kolmogorov-Smirnov test, a histogram, and a boxplot. Two independent groups were compared using an independent-samples t-test or the Mann-Whitney U test, depending on whether the assumptions were met. To assess the association between two categorical variables, Pearson's chi-square test or Fisher's exact test was used. A two-tailed p-value <0.05 was considered to indicate statistical significance. All statistical analyses were performed using IBM SPSS Statistics software, version 23.0.

Results

One hundred and eighty-six DS patients underwent CHD surgery during the study period, of whom 175 with accessible medical data were included in the study. Seventy five patients (42.8%) were male and 100 (57.2%) were female. The median age of the patients was 7 months (range, 1-86 months). Among 175 patients, a total of 276 cardiac diagnoses were recorded. The most common cardiac pathology was ASD (19.2%), followed by endocardial cushion defect (18.7%) and VSD (11.3%) (Table 1). In patients with multiple defects, the most common defects were ASD and VSD (22.8%).

Surgical technical information was available for 175 patients. According to the RACHS-1 score, 27 patients (15.4%) were in category 1, 73 patients (41.7%) were in category 2, 74 patients (42.3%) were in category 3, and one patient (0.6%) was in category 4. Surgical procedure risk groups, mortality, and survival rates by RACHS-1 risk group are presented in Table 2.

SIRS developed in 61 patients (34.9%) during the postoperative period. Mortality was observed in 50.8% of patients with SIRS. These patients accounted for 57% of the total mortality. The relationship between the development of SIRS and mortality was considered statistically significant (p<0.001). One hundred and fifty eight patients required blood

transfusion during and after the operation, and 17 patients did not require transfusion. Transfusion was required in 98 of 110 survivors (89.2%) and in 46 of 48 non-survivors (96.3%). There was no statistically significant association between the need for blood transfusion and mortality ($p=0.154$). A total of seven patients (3.8%) required extracorporeal membrane oxygenation (ECMO) for low cardiac output syndrome; two patients were weaned from ECMO during the postoperative period.

Some patients had more than one accompanying anomaly or disease. A total of 79 additional diagnoses were identified in 70 patients, some of whom had more than one comorbidity. The most common of these was hypothyroidism (29 patients, 36.7%). When the effect of comorbidity on patient mortality was examined, surviving patients had a higher comorbidity burden. Mortality was observed in 34.9% of patients without comorbidity (106 patients), compared with 23.2% of patients with comorbidity (69 patients) ($p<0.05$).

After the surgical procedure, the median mechanical ventilatory length of stay (MV LOS) for all patients was 2 days.

MV LOS was 2 days (min: 0, max: 60 days) in survivors and 4 days (min: 0, max: 52 days) in non-survivors ($p<0.05$).

The median PICU LOS for all patients was 6 days. While the median length of stay in the intensive care unit was 6 days (min: 2 days, max: 114 days) for surviving patients, it was 8 days (min: 5 days, max: 108 days) for non-survivors ($p=0.06$).

Intraoperative cardiac pump times were recorded for 69 patients. Median pump time was 83 minutes (range: 1-256) in survivors and 71.5 minutes (range: 14-213) in non-survivors. There was no statistically significant relationship between intraoperative pump time and mortality (survivors vs. non-survivors; $p=0.508$). In total, seven patients required ECMO, and two of them could be weaned from ECMO.

Fifty-three (30.3%) of 175 patients died, and 36 (67.2%) of them were female. When we examined the RACHS-1 grouping among the patients who died, we found that patients in category 3 constituted 66% of deaths. Compared with categories 1 and 2, patients undergoing category 3 surgical procedures have a significantly higher risk of death ($p<0.001$). All identified risk factors are detailed in Table 3.

Table 1. The most common cardiac pathological diagnoses of patients

| Cardiac pathology | n | Percent | Percent of cases |
|---------------------------------|----|---------|------------------|
| Atrial septal defect | 80 | 19.2% | 45.7% |
| Endocardial cushion defect | 78 | 18.7% | 44.6% |
| Ventricular septal defect | 47 | 11.3% | 26.9% |
| Tetralogy of fallot | 40 | 9.6% | 22.9% |
| Patent ductus arteriosus | 15 | 3.6% | 8.6% |
| Double outlet right ventricle | 12 | 2.9% | 6.9% |
| Transposition of great arteries | 4 | 1% | 2.3% |

Table 2. Surgical procedure risk groups, mortality, and survival rates

| | | RACHS-1 categories* | | | | Total (n) |
|--------------|----------|---------------------|------------|------------|----------|-----------|
| | | 1 | 2 | 3 | 4 | |
| Survivor | Patients | 22 (18.0%) | 60 (49.2%) | 39 (32.0%) | 1 (0.8%) | 122 |
| Non-survivor | Patients | 5 (9.4%) | 13 (24.5%) | 35 (66%) | 0 (0.0%) | 53 |
| Total | Patients | 27 (15.4%) | 73 (41.7%) | 74 (42.3%) | 1 (0.6%) | 175 |

*: Risk adjusted classification for congenital heart surgery, RACHS-1: The risk adjustment for congenital heart surgery

Table 3. Risk factors of the patients according to preoperative and postoperative features

| Risk factors | Survivor | Non-survivor | p-value |
|------------------------------|------------|--------------|---------|
| SIRS; n, (%) | 33 (26.1%) | 30 (56.6%) | <0.001 |
| Blood transfusion; n, (%) | 98 (89.2%) | 46 (96.3%) | =0.154 |
| RACHS-1 category 3,4; n, (%) | 35 (66%) | 40 (32.8%) | <0.001 |
| Comorbidity; n, (%) | 122 (70%) | 53 (30%) | <0.005 |
| MV LOS; mean ± SD (day) | 4.5±8.2 | 8.5±11 | <0.005 |
| LOS PICU; mean ± SD (day) | 8.8±10.5 | 13.6±15.2 | =0.06 |
| Pump time; mean ± SD (min) | 85.8±45.9 | 79.5±39.9 | =0.508 |

SIRS: Systemic inflammatory response syndrome, RACHS-1: The risk adjustment for congenital heart surgery, MV LOS: Mechanical ventilatory length of stay, LOS PICU: Length of stay pediatric cardiac intensive care unit, SD: Standard deviation

Discussion

DS patients frequently have cardiac pathologies, which are the leading cause of mortality and morbidity. In the current study, 57.1% of the patients were female; a total of 58 patients died, of whom 36 (67.9%) were female. The most common cardiac abnormality in DS patients was ASD. Some of the patients had more than one cardiac abnormality. Most surgical procedures were classified in RACHS-1 categories 2 and 3. As expected, the mortality rate was higher in high-risk procedures. The RACHS-1 cardiac surgical procedure group had the highest number of patients in category 3, and an increase in risk category caused increased mortality. Mortality was higher in patients who developed SIRS. When comorbidity was assessed, the most common comorbidity was hypothyroidism, and comorbidities were less common in patients who died. Patients who died had longer stays on MV and in intensive care. In total, 7 patients required ECMO, and two were weaned from ECMO.

CHD is observed in 40-50% of individuals with DS and is an important determinant of survival.⁶ The actual rate and relative frequency of certain anomalies vary with the method of detection.⁶ The most common cardiac malformation reported in DS was an endocardial cushion defect, followed by ASD, VSD, PDA, aortic coarctation, and TOF.⁷ In our study, consistent with previous reports, the most common cardiac pathologies were ASD and endocardial cushion defects. All patients diagnosed with DS during the prenatal and postnatal periods should be examined for these defects.

RACHS-1 is a widely used methodology for risk stratification in pediatric and congenital cardiac surgery.⁵ This risk classification enables rare surgical operations to be classified into homogeneous risk categories. Higher categories in the classification indicate that riskier surgeries are performed. In our study, surgical procedures were most frequently classified in risk categories 2 and 3. A statistically significant association was found between increasing risk group level and mortality. Mortality rates increase as the RACHS-1 risk category of operations performed in patients with DS increases.

It is known that DS patients are vulnerable to infections and SIRS, and studies on the immune system of DS have shown multiple, complex lymphoproliferative and myeloproliferative alterations.⁸ When investigating why immunodeficiency is seen at such high frequency in children with DS, researchers have expressed differing opinions. Ferrari and Stagi⁹ documented a normal proportion of CD4+ T-cells, whereas the percentage of suppressor-cytotoxic CD8+ lymphocytes was significantly increased. In contrast, Corsi et al.¹⁰ showed that peripheral CD4+ T-cells were lower in children with DS, whereas mean values of cytotoxic CD8+ T-cells were close to

the normal range. 34.9% of our patients experienced SIRS postoperatively. Faria et al.¹¹ reported a significant association between severe infections (particularly pneumonia and sepsis) and CHD. In this study, SIRS was present in 85% of DS patients with CHD. DS patients with CHD must be closely monitored for development of infection or SIRS, especially in the postoperative period. Infection control measures must be implemented, and PICU LOS must be shortened to prevent the development of infections.

Children with DS are at an increased risk for certain health problems, including cardiovascular abnormalities, head and neck abnormalities, extremity problems, behavioral and psychiatric disorders, gastrointestinal tract anomalies, growth deficiency, obesity, ophthalmologic disorders, hearing impairment, endocrine abnormalities, hematologic disorders (e.g., acute lymphoblastic leukemia), pulmonary complications, and immunodeficiency.¹² When additional anomalies were investigated in our patients, hypothyroidism was the most common (36.7%). According to the literature, the prevalence of CHD in DS has been reported to range from 2% to 16.5%. This considerable variation may be attributed to differences in diagnostic methods and criteria, study sample sizes, and the periods during which the investigations were carried out.¹³ Although additional anomalies would conventionally be considered unfavorable, we observed an inverse association between their presence and mortality in our patients. We considered mortality in our patients to be associated with the underlying CHD rather than with other comorbidities.

Previous studies have reported that long-term mechanical ventilation is a significant predictor of mortality after cardiac surgery.¹⁴ Prolonged MV LOS is closely associated with multi-organ failure and mortality. In the current study, we demonstrated that MV LOS was longer in non-survivors.

ECMO provides pivotal perioperative support to pediatric patients undergoing cardiac surgery.¹⁵ Extracorporeal life support organization guidelines regarding the indication for ECMO in patients with a DS diagnosis do not specify any contraindications.¹⁶ Only lethal chromosomal abnormalities (e.g., trisomy 13 or 18) are contraindications to ECMO. In a large cohort study conducted by Cashen et al.¹⁷ 623 of 46.862 ECMO patients were diagnosed with DS. The prevalence of patients diagnosed with DS and undergoing ECMO was 13.5 per 1.000. There were no differences in hospitalization and mortality rates between these patients and non-DS patients. In our study, seven patients required ECMO, of whom two were weaned from ECMO. DS is not a contraindication to ECMO, and ECMO can be beneficial when applied in a timely manner for appropriate indications.

Study Limitations

A limitation of this study is that it was conducted at a single-center, and some patients' information could not be retrieved because of the extended study period.

Conclusion

This single-center study revealed the pattern of CHD in a specific group of patients with DS and the risk factors associated with cardiac surgery. It was found that postoperative SIRS and high-risk surgical procedures are linked to an increased risk of mortality.

Ethics

Ethics Committee Approval: Ethical approval for this study was obtained from the Hacettepe University Non-Clinical Research Ethics Committee (approval no: 2019/08-27, date: 19.03.2019).

Informed Consent: All participants were informed about the study, and written consent was obtained.

Footnotes

Authorship Contributions

Surgical and Medical Practises: A.A., H.H.A., M.Y., Concept: S.Y., B.B., Design: S.K., B.B., Data Collection or Processing: U.B.M., Analysis or Interpretation: S.Y., Literature Search: S.Y., U.B.M., Writing: S.Y.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

References

1. Ostermaier KK. Down syndrome: clinical features and diagnosis. *UpToDate*. 2019;1-29.
2. Santoro SL, Steffensen EH. Congenital heart disease in Down syndrome - a review of temporal changes. *Journal of Congenital Cardiology*. 2021;5:1-14.
3. Irving CA, Chaudhari MP. Cardiovascular abnormalities in Down's syndrome: spectrum, management and survival over 22 years. *Arch Dis Child*. 2012;97:326-30.
4. Anil AB, Özçifçi G, Havan M, Yetimakman F, Çeleğen M, ve ark. Postoperatif pediatrik kardiyak yoğun bakım protokolü 2025. *Türk Çocuk Acil Tıp ve Yoğun Bakım Derneği*. 2025;1-49.
5. Welke K, Karamlou T, Ungerleider RM, Jacobs JP. How to interpret and use outcome data. *Critical Heart Disease in Infants and Children*. Elsevier;2019:24-34.
6. Korlimarla A, Hart SJ, Spiridigliozzi GA, Kishnani PS. Down syndrome. *Cassidy and Allanson's Management of Genetic Syndromes*. 2021:355-87.
7. Ödek Ç, Tutar E, Uysalel A, Ateş C, Eyileten Z, et al. Perioperative factors associated with hyperglycemia after pediatric cardiac surgery and impact of hyperglycemia on morbidity and mortality. *Turk J Pediatr*. 2018;60:497-505.
8. Szczawińska-Popłonyk A, Popłonyk N, Awdi K. Down syndrome in children: a primary immunodeficiency with immune dysregulation. *Children (Basel)*. 2024;11:1251.
9. Ferrari M, Stagi S. Autoimmunity and genetic syndromes: a focus on Down syndrome. *Genes (Basel)*. 2021;12:268.
10. Corsi MM, Ponti W, Venditti A, Ferrara F, Baldo C, et al. Proapoptotic activated T-cells in the blood of children with Down's syndrome: relationship with dietary antigens and intestinal alterations. *Int J Tissue React*. 2003;25:117-25.
11. Faria PF, Nicolau JAZ, Melek M, Oliveira NP, Bermudez B, et al. Association between congenital heart defects and severe infections in children with Down syndrome. *Rev Port Cardiol*. 2014;33:15-8.
12. Messerlian GM, Halliday JV, Palomaki GE. Down syndrome: Overview of prenatal screening [Internet]. Accessed: July 1, 2024. Available at: https://www.uptodate.com/contents/down-syndrome-overview-of-prenatal-screening?search=down%20syndrome&topicRef=2917&source=see_link
13. Gorini F, Coi A, Pierini A, Assanta N, Bottoni A, et al. Hypothyroidism in patients with Down syndrome: prevalence and association with congenital heart defects. *Children*. 2024;11:513.
14. Fernandez-Zamora MD, Gordillo-Brenes A, Banderas-Bravo E, Arboleda-Sánchez JA, Hinojosa-Pérez R, et al. Prolonged mechanical ventilation as a predictor of mortality after cardiac surgery. *Respir Care*. 2018;63:550-7.
15. Botan E, Durak Aslan A, Gün E, Havan M, Dikmen N, et al. Extracorporeal membrane oxygenation after pediatric cardiac surgery: a single-center experience. *Turk Arch Pediatr*. 2024;59:358-63.
16. Guerguerian AM, Sano M, Todd M, Honjo O, Alexander P, et al. Pediatric extracorporeal cardiopulmonary resuscitation ELSO Guidelines. *ASAIO J*. 2021;67:229-37. Erratum in: *ASAIO J*. 2022;68:e130.
17. Cashen K, Thiagarajan RR, Collins JW Jr, Rycus PT, Backer CL, et al. Extracorporeal membrane oxygenation in pediatric trisomy 21: 30 years of experience from the extracorporeal life support organization registry. *J Pediatr*. 2015;167:403-8.



Short First-aid Training Improves Parental Knowledge of Pediatric Head Trauma: A Pilot Study

Kısa İlk Yardım Eğitimi Ebeveynlerin Pediyatrik Kafa Travması Bilgisini Artırıyor: Pilot Çalışma

© Semra Söngüt¹, © Hacer Delibaş², © Zehra Ünal³

¹Hitit University İskilip Vocational School, Department of Medical Services and Techniques, Çorum, Türkiye

²Ministry of Health, Söğütüevler Family Health Center, Çorum, Türkiye

³Hitit University Faculty of Health Sciences, Department of Nursing, Çorum, Türkiye

Abstract

Introduction: Pediatric head trauma is one of the leading causes of emergency visits and can result in serious complications. Parents, often the first responders in such situations, generally lack adequate knowledge of appropriate first-aid. Educational interventions may help bridge this gap and improve emergency preparedness. This study aimed to evaluate the effectiveness of a short-duration first-aid training program in improving parents' knowledge of pediatric head trauma.

Methods: A pre-test-post-test interventional design was used to assess the effectiveness of first-aid training. The study was conducted among 101 parents at a primary healthcare center in Türkiye. Participants received a 15-minute structured first-aid training focused on the signs and symptoms of pediatric head trauma and on appropriate emergency responses. A 13-item knowledge questionnaire was administered before and after the training. Data were analyzed using paired samples and independent-samples t-tests, as appropriate.

Results: The mean total knowledge score increased significantly from 10.47±1.54 (pre-test) to 11.81±1.52 (post-test) ($p<0.001$). The effect size (Cohen's $d=0.88$) indicated a strong impact. Comparison of sociodemographic characteristics and average knowledge scores between groups showed statistical significance ($p<0.001$). Parents of children who had experienced head trauma or emergency department visits exhibited notably higher post-test scores.

Conclusion: Short, structured first-aid training significantly improves parental knowledge of pediatric head trauma. Incorporating such programs into routine pediatric and community health services may enhance early recognition and response to head injuries.

Öz

Giriş: Pediyatrik kafa travması acil servis ziyaretlerinin önde gelen nedenlerinden biridir ve ciddi komplikasyonlara yol açabilir. Genellikle bu gibi durumlarda ilk müdahale bulunan bireyler ebeveynler olduğu için, doğru ve etkili bir ilk yardım konusunda yeterli bilgiye sahip olmaları önemlidir. Eğitimsel müdahaleler bilgi boşluğu kapatmaya ve acil durum hazırlığını iyileştirmeye yardımcı olabilir. Bu çalışma, ebeveynlerin pediyatrik kafa travması hakkındaki bilgilerini artırmada kısa süreli bir ilk yardım eğitim programının etkinliğini değerlendirmeyi amaçlamaktadır.

Yöntemler: İlk yardım eğitiminin etkinliğini değerlendirmek amacıyla ön-test-son-test müdahale tasarımı kullanıldı. Çalışma, Türkiye'deki bir birincil sağlık merkezinde 101 ebeveyn ile yürütüldü. Katılımcılar, pediyatrik kafa travmasının belirtileri, semptomları ve uygun acil müdahalesine odaklanan 15 dakikalık yapılandırılmış bir ilk yardım eğitimi aldılar. Eğitimden önce ve sonra 13 maddelik bir bilgi anketi uygulandı. Veriler bağımsız örneklem t-testi, eşleştirilmiş t-testi ve etki büyüklüğü hesaplamaları kullanılarak analiz edildi.

Bulgular: Ortalama toplam bilgi puanı 10,47±1,54'ten (ön-test) 11,81±1,52'ye (son-test) önemli ölçüde arttı ($p<0,001$). Etki büyüklüğü (Cohen'in $d=0,88$) güçlü bir etki gösterdi. Sosyodemografik özellikler ile bilgi puan ortalamalarının gruplar arası karşılaştırılması istatistiksel olarak ileri düzeyde anlamlılık gösterdi ($p<0,001$). Kafa travması veya acil servis ziyaretleri yaşayan çocukların ebeveynleri test sonrası belirgin şekilde daha yüksek puanlar gösterdi.

Sonuç: Kısa, yapılandırılmış ilk yardım eğitimi ebeveynlerin pediyatrik kafa travması hakkındaki bilgisini önemli ölçüde yükseltti. Bu tür programların rutin pediyatrik ve toplum sağlık hizmetlerine dahil edilmesi, kafa yaralanmalarına erken tanı ve müdahaleyi

Address for Correspondence/Yazışma Adresi: Semra Söngüt, MD, Hitit University İskilip Vocational School, Department of Medical Services and Techniques, Çorum, Türkiye

E-mail: semrasongut@hitit.edu.tr **ORCID ID:** orcid.org/0000-0003-1952-7980

Received/Geliş Tarihi: 21.06.2025 **Accepted/Kabul Tarihi:** 19.11.2025 **Epub:** 25.02.2026 **Publication Date/Yayınlanma Tarihi:** 01.04.2026

Cite this article as: Söngüt S, Delibaş H, Ünal Z. Short first-aid training improves parental knowledge of pediatric head trauma: a pilot study. J Pediatr Emerg Intensive Care Med. 2026;13(1):23-31



Abstract

Future programs should combine theoretical and hands-on training to reinforce learning and address persistent knowledge gaps. Integrating such interventions into primary healthcare services and parental education will enhance community preparedness and empower parents to respond effectively to pediatric emergencies.

Keywords: First-aid, parental knowledge, parental training, pediatric head trauma

Introduction

Head trauma is a leading cause of emergency department visits and mortality among young children, accounting for 39.7% of pediatric traumatic injuries.^{1,2} The Centers for Disease Control and Prevention report that 7.0% of children aged 3-17 experience a serious head injury.³ The percentage of children suffering a significant head injury increases with age and is almost three times higher in children aged 15-17 (11.7%) than in children aged 3-5 (4.0%).³ In addition, head trauma causes 600.000 emergency department visits and 7.400 deaths among children under 18 years of age each year worldwide.⁴ The mortality rate due to traumatic brain injury (TBI) is higher in children under 4 years of age than in those aged 5-14 years; the annual mortality in the younger group is 5 per 100.000 children.⁵⁻⁷

A head trauma of the same severity can lead to worse outcomes in children than in adults.^{8,9} It has been reported that even in children without obvious neurological deficits resulting from head trauma, impairments in academic performance, attention, concentration, memory, and executive functions may be observed, and some of these symptoms may appear only months or years after the initial injury.^{2,5,7-9} Therefore, it is not possible to know when, where, or how these traumas, which can significantly affect the lives of children and their parents, may occur. For this reason, it is important that parents, who spend most of their time with their children, know appropriate approaches and first-aid interventions in the event of any accident or injury, including head trauma.^{10,11} However, no study in the literature specifically addresses how parents can administer first-aid to their children who have sustained head trauma. Given that early and appropriate first-aid interventions can prevent complications, parental education is a key component of pediatric emergency preparedness.

Nurses play a critical role in educating caregivers about pediatric emergencies, including head trauma. However, structured first-aid training programs are not widely

Öz

artırılabilir. Gelecekteki programlar, öğrenmeyi pekiştirmek ve kalıcı bilgi eksikliklerini gidermek için teorik ve uygulamalı eğitimi birleştirmelidir. Bu tür müdahalelerin birincil sağlık hizmetlerine ve ebeveyn eğitimine entegre edilmesi, toplumun hazırlığını artıracak ve ebeveynlerin pediatrik acil durumlara etkili bir şekilde müdahale etmelerini sağlayacaktır.

Anahtar Kelimeler: İlk yardım, ebeveyn bilgisi, ebeveyn eğitimi, pediatrik kafa travması

implemented in clinical practice. This study aims to bridge this gap by evaluating the impact of a first-aid training program for parents on their knowledge of pediatric head trauma.

Hypothesis of the Research

H₁: First-aid training significantly improves parents' knowledge regarding pediatric head trauma.

Materials and Methods

Study Design and Participants

The study was conducted from November 2023 to May 2024 at a primary health care institution in Türkiye. A pre-post test interventional design was used to assess the effectiveness of first-aid training. To determine the required sample size, an a priori power analysis was conducted using G*Power 3.1 software. With an effect size of 0.5, an alpha of 0.05, and 80% power, a minimum of 88 participants were required. To allow for potential dropouts, 101 participants were included to ensure sufficient statistical power.

The inclusion criteria were:

- Being the parent or primary caregiver of a child under 18 years old.
- Being able to read and write in Turkish.
- Willingness to participate and provide informed consent.

Exclusion criteria included parents who had formal first-aid training or those with medical backgrounds (e.g., healthcare professionals).

Ethical Approval

The study was carried out in accordance with the Declaration of Helsinki. Ethics committee approval for this research was obtained from the Hitit University Non-Interventional Research Ethics Committee (approval no: 2023-17, date: 01.11.2023).

Strengths of Study

This study contributes to the limited body of literature on first-aid training for parents specifically focused on pediatric head trauma. Its strengths lie in targeted intervention design, structured training, and pre- and post-test evaluations with measurable outcomes. The inclusion of sociodemographic subgroup analyses deepens understanding of which parental groups may benefit most from such training. Although similar studies have examined general first-aid education, this study makes a novel contribution by addressing a high-risk, high-impact topic in pediatric emergency care in a community-based setting. Furthermore, ensuring the validity of the survey forms and, in the future, developing them into a scale could be considered important methodological contributions.

Implementation of the Study

The first-aid training was developed based on the recommendations of the European Resuscitation Council First-aid Guidelines.¹² Consent was obtained from parents who presented to the primary health care center for reasons such as vaccination or treatment, to ascertain their willingness to participate in the study. The training included:

- A 15-minute interactive session led by a certified first-aid instructor. The training was intentionally designed as a 15-minute intervention to ensure feasibility and accessibility within primary health care settings, where parents often have limited time. Similar short-format educational models have been shown to improve caregivers' knowledge of first-aid topics.^{10,11} This duration was therefore considered both practical and sufficient for delivering essential first-aid information on pediatric head trauma.
- Visual educational poster detailing signs, symptoms, and immediate actions for head trauma.
- Q&A session where parents could ask clarifying questions.

Participants completed a pre-test before the training and a post-test immediately after.

Data Collection Instruments

The study utilized a self-administered questionnaire, which included:

- A demographic information form (age, education, prior knowledge of first-aid, history of child head trauma, etc.).
- A 13-item head trauma first-aid knowledge test (true/false format) was developed based on existing literature.^{7,11} To determine the parents' knowledge levels regarding first-aid for head trauma, responses were scored as 1 point for a correct answer and 0 points for an incorrect answer.

Validity and Reliability

Content validity was ensured by an expert panel of two emergency physicians, two pediatricians, and two first-aid instructors. A pilot study involving 10 parents was conducted, and the questionnaire was revised for clarity. Cronbach's alpha coefficient for the knowledge test was 0.78, indicating acceptable reliability.

Statistical Analysis

Data were analyzed using SPSS 21.0. The distribution of the data was assessed using the Shapiro-Wilk test, which indicated a normal distribution. Therefore, parametric tests were used in the analyses. Descriptive statistics were summarized as the mean, standard deviation, and minimum and maximum for numerical variables, and as number and percentage (%) for categorical variables. To compare mean scores, the paired t-test was used for within-group comparisons (before and after training), and the independent-samples t-test (for two groups) and one-way analysis of variance (for three or more groups) were used for between-group comparisons across sociodemographic characteristics. Effect size (r) was evaluated according to Cohen's (1988) classification: $r=0.1$ (small), $r=0.3$ (medium), $r=0.5$ (large). Statistical significance was set at $p<0.05$. Additionally, subgroup analyses were conducted to examine the impact of child-related variables (e.g., trauma history, gender, emergency room visit status) on parental awareness. These variables were included in the analysis because they are among the factors reported in the literature as influencing parental awareness and first-aid responses.

Results

In the study, the mean total knowledge score of parents regarding first-aid for head trauma was found to be 10.47 ± 1.54 before the training and 11.81 ± 1.52 after the training. The effect size (Cohen's $d = 0.88$) indicated a strong effect. The comparison of the mean scores before and after was highly significant ($p<0.001$; Figure 1).

Table 1 presents a comparison of pre-test and post-test knowledge scores by sociodemographic variables. The mean age of the parents was 29.3 ± 6.0 years; the majority were mothers (94.1%), were married (97.0%), and had at least a high school education (67.4%). Most participants were unemployed (70.3%) and lived in nuclear families (89.1%). The training significantly improved knowledge scores across all sociodemographic subgroups ($p<0.001$; Table 1).

Table 2 presents the relationship between children’s head trauma history and parents’ first-aid knowledge scores. Overall, 31.7% of parents reported that their child had previously experienced head trauma, most commonly due to falls from a height (90.6% of cases). The mean age of affected children was 2.9±1.8 years, and 51.5% were male. The training significantly improved knowledge scores in all subgroups (p<0.001 for all within-group comparisons). Additionally, parents whose children had experienced head trauma had higher post-test scores (12.16±1.09) compared with those whose children had not (11.63±1.67), although the difference did not reach statistical significance (p>0.05). Notably, parents who previously sought emergency care for head trauma had significantly higher post-test scores (p=0.049). Similarly, parents of male children who had sustained head trauma scored significantly higher on the post-test compared with parents of female children who had sustained head trauma (p=0.001; Table 2).

The comparison of item score averages for parents’ knowledge of first-aid for head trauma before and after the training is shown in Table 3. Average total correct answer scores for parents’ knowledge of first-aid for head trauma increased in most cases, compared with before the intervention. However, the comparison of item score averages for items 1, 3, 4, 6, 7, 10, and 12 was found to be statistically significant (p<0.05; Table 3).

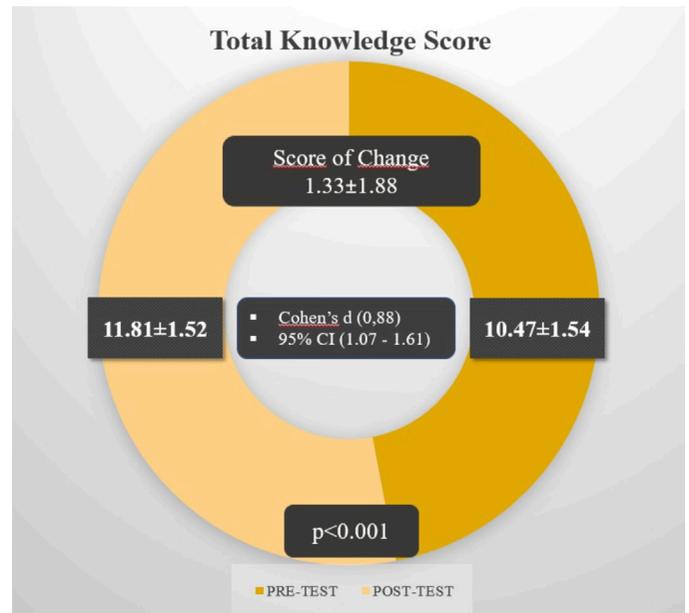


Figure 1. Comparison of parents’ total knowledge score averages regarding first-aid in head traumas
CI: Confidence interval

| Table 1. Sociodemographic characteristics of parents and comparison of knowledge scores before and after training (n=101) | | | | | | | |
|---|------------------|---------|------------------|---------------------------|------------------|---------------------------|-----------------------------|
| Descriptive characteristics | $\bar{X} \pm SD$ | Min-max | Pre-test | | Post-test | | Test/p-value ^b |
| | | | $\bar{X} \pm SD$ | Test/p-value ^a | $\bar{X} \pm SD$ | Test/p-value ^a | |
| Parent’s age | 29.31±5.98 | 18-45 | 10.47±1.54 | 2.379 <0.001 | 11.81±1.52 | 2.831 <0.001 | -29.698 <0.001 |
| Child’s age | 5.05±5.10 | 0-18 | 10.50±1.37 | 2.379 <0.001 | 11.50±1.04 | 1.402 0.039 | 9.803 <0.001 |
| | n | % | | | | | |
| Participating parent | | | | | | | |
| Mother | 95 | 94.1 | 10.45±1.55 | -0.583 0.561 | 11.75±1.55 | -1.420 0.159 | 61.014 <0.001 |
| Father | 6 | 5.9 | 10.83±1.47 | | 12.66±0.51 | | |
| Level of education | | | | | | | |
| Primary school | 16 | 15.8 | 10.62±0.31 | 0.192 | 12.18±0.83 | 1.572 | 37.649 |
| Secondary school | 20 | 19.8 | 10.20±2.09 | 0.965 | 12.00±1.58 | 0.176 | <0.001 |
| High school | 32 | 31.8 | 10.46±1.50 | | 11.96±1.30 | | |
| Associate degree | 16 | 15.8 | 10.56±1.36 | | 10.87±2.02 | | |
| Undergraduate | 17 | 16.8 | 10.56±1.45 | | 11.81±1.68 | | |
| Marital status | | | | | | | |
| Single | 3 | 3.0 | 10.66±0.57 | 0.217 | 12.33±0.57 | 0.598 | 54.803 |
| Married | 98 | 97.0 | 10.46±1.56 | 0.829 | 11.79±1.54 | 0.551 | <0.001 |
| Working status | | | | | | | |
| Working | 30 | 29.7 | 10.80±1.76 | 1.378 | 11.96±1.42 | 0.660 | 52.708 |
| Not working | 71 | 70.3 | 10.33±1.43 | 0.171 | 11.74±1.57 | 0.511 | <0.001 |

Table 1. Continued

| Descriptive characteristics | $\bar{X} \pm SD$ | Min-max | Pre-test | | Post-test | | Test/p-value ^b |
|---|------------------|---------|------------------|---------------------------|------------------|---------------------------|---------------------------|
| | | | $\bar{X} \pm SD$ | Test/p-value ^a | $\bar{X} \pm SD$ | Test/p-value ^a | |
| Income level | | | | | | | |
| Income is less than my expenses | 19 | 18.8 | 10.63±1.37 | 0.120 0.887 | 12.00±0.81 | 0.530 0.590 | 51.210 <0.001 |
| Income is equal to my expenses | 67 | 66.3 | 10.43±1.60 | | 11.83±1.57 | | |
| Income is more than my expenses | 15 | 14.9 | 10.46±1.59 | | 11.46±1.99 | | |
| Family type | | | | | | | |
| Nuclear family | 90 | 89.1 | 10.48±1.54 | -0.021 | 11.84±1.46 | 0.671 | 58.636 <0.001 |
| Traditional (extended) family | 11 | 10.9 | 10.50±1.64 | 0.983 | 11.50±2.12 | 0.504 | |
| Total number of children | | | | | | | |
| 1 | 52 | 51.5 | 10.84±1.30 | 3.654 0.029 | 11.67±1.58 | 0.583 0.560 | 9.160 <0.001 |
| 2 | 28 | 27.7 | 10.25±1.48 | | 11.85±1.79 | | |
| 3 and above | 21 | 20.8 | 9.85±1.95 | | 12.09±0.88 | | |
| Total number of people living in the house | | | | | | | |
| 3 | 45 | 44.6 | 10.81±1.34 | 0.911 0.477 | 11.79±1.48 | 1.000 0.422 | 38.546 <0.001 |
| 4 | 28 | 27.6 | 10.32±1.46 | | 12.10±1.37 | | |
| 5 | 24 | 23.8 | 10.12±2.00 | | 11.70±1.45 | | |
| 6 and above | 4 | 4.0 | 10.50±0.57 | | 10.50±3.10 | | |
| Place of residence | | | | | | | |
| Province | 97 | 95.0 | 10.41±1.54 | -1.698 | 11.77±1.55 | -0.933 | 50.817 |
| District | 4 | 4.0 | 11.75±1.25 | 0.093 | 12.50±0.57 | 0.353 | <0.001 |
| Child has chronic disease | | | | | | | |
| Yes* | 96 | 95.0 | 10.43±1.56 | -1.076 0.285 | 11.81±1.56 | 0.018 0.986 | 61.572 <0.001 |
| No | 5 | 5.0 | 11.20±1.09 | | 11.80±0.44 | | |

*: Independent sample t-test for pairwise comparisons, ANOVA for three or more comparisons, †: Paired t-test; statistical significance: p<0.05, ‡: heart: n=3; eye: n=1; asthma: n=1; kidney: n=1; epilepsy: n=1, Marshall syndrome: n=1; immunodeficiency: n=1, SD: Standard deviation

Table 2. Distribution of children's head trauma history and parents' knowledge of first-aid in head trauma

| Items | n | % | Pre-test | | Post-test | | Test/p-value ^b |
|--|-------------------------------|------|------------------|---------------------------|------------------|---------------------------|---------------------------|
| | | | $\bar{X} \pm SD$ | Test/p-value ^a | $\bar{X} \pm SD$ | Test/p-value ^a | |
| Child has head trauma | | | | | | | |
| Yes | 32 | 31.7 | 10.74±1.26 | -1.225 0.224 | 12.16±1.09 | -1.594 | 52.061 |
| No | 69 | 68.3 | 10.33±1.65 | | 11.63±1.67 | 0.114 | <0.001 |
| Number of head injuries the child has had since birth | Mean ± SD 1.27±0.73 | | 10.36±1.43 | 0.270 0.788 | 12.54±0.93 | -1.746 0.084 | 52.840 <0.001 |
| Cause of head trauma | | | | | | | |
| Fall from height (such as balcony, bed, window) | 29 | 90.6 | 10.86±1.24 | 1.490 0.242 | 12.13±1.12 | 0.374 0.691 | 38.871 <0.001 |
| Accident/injury with a motorbike | 3 | 9.4 | 9.50±2.12 | | 12.50±0.07 | | |
| Age of the child at the time of the trauma | Mean ± SD 2.93±1.83 | | 10.66±1.22 | 0.000 1.000 | 12.33±0.81 | -1.859 0.086 | 19.550 <0.001 |
| Gender of traumatized child | | | | | | | |
| Female | 15 | 48.5 | 10.62±1.20 | -0.833 0.411 | 11.56±1.26 | -3.487 0.001 | 40.775 <0.001 |
| Male | 17 | 51.5 | 11.00±1.36 | | 12.70±0.46 | | |
| Knowing first-aid for head trauma | | | | | | | |
| Yes | 12 | 11.9 | 10.50±1.54 | 0.536 0.593 | 11.50±1.73 | 0.752 0.454 | 58.865 <0.001 |
| No | 89 | 88.1 | 10.25±1.60 | | 11.85±1.50 | | |
| Emergency room visit due to head trauma | | | | | | | |
| Yes | 25 | 24.8 | 10.80±1.22 | -1.213 0.228 | 12.32±1.02 | -1.970 0.049 | 59.643 <0.001 |
| No | 76 | 75.2 | 10.36±1.63 | | 11.64±1.63 | | |

Table 2. Distribution of children's head trauma history and parents' knowledge of first-aid in head trauma

| Items | n | % | Pre-test | | Post-test | | Test/p-value ^b |
|--|----|------|------------------|--------------|------------------|--------------|----------------------------|
| | | | $\bar{X} \pm SD$ | Test/p-value | $\bar{X} \pm SD$ | Test/p-value | |
| Hospitalization for head trauma | | | | | | | |
| Yes | 3 | 3.0 | 11.33±0.57 | -0.975 | 13.0±0.0 | -1.373 | 61.668 <0.001 |
| No | 98 | 97.0 | 10.44±1.56 | 0.332 | 11.77±1.53 | 0.173 | |

∗: Independent sample t-test for pairwise comparisons, ANOVA for three or more comparisons, ∗∗: Paired t-test; statistical significance: p<0.05, SD: Standard deviation

Table 3. Parents' first-aid knowledge item score means in head trauma

| Items | Pre-test | Post-test | Score of change | p-value ^{∗∗} |
|--|-----------|-----------|-----------------|-----------------------|
| 1. If my child loses consciousness after receiving a blow to the head, I think it is a head injury. | 0.93±0.25 | 0.99±0.09 | 0.05±0.27 | 0.033 |
| 2. If my child vomits forcefully when he/she is struck on the head, I think he/she has a head injury. | 0.99±0.09 | 0.98±0.14 | 0.00±0.17 | 0.566 |
| 3. If my child sustains a blow to the head with resulting swelling, I would consider it a head injury. | 0.85±0.35 | 0.95±0.21 | 0.09±0.36 | 0.007 |
| 4. If my child sustains a blow to the head and a black-and-blue discoloration is present under the eye and behind the ear, I would suspect a head injury. | 0.79±0.40 | 0.89±0.31 | 0.09±0.45 | 0.032 |
| 5. If my child utters meaningless words after he/she sustains a blow to the head, I would suspect that he/she has a head injury. | 0.95±0.21 | 0.94±0.23 | 0.00±0.22 | 0.657 |
| 6. If my child makes sounds such as crying or moaning when he/she receives a blow to the head, I would suspect he/she has a head injury. | 0.69±0.46 | 0.83±0.37 | 0.13±0.46 | 0.004 |
| 7. If my child has a blow to the head and there are any broken bones or bleeding in the head, I apply pressure directly to the area with a cloth. | 0.23±0.47 | 0.67±0.47 | 0.43±0.60 | <0.001 |
| 8. If my child experiences a blow to the head and, within 48 hours, develops any of the following: a headache; pain in the neck or back; tingling or loss of sensation in the hands and fingers; or fluid discharge from the nose or ears, I consider the child to have a head injury. | 0.93±0.25 | 0.96±0.19 | 0.02±0.33 | 0.368 |
| 9. If I suspect that my child has sustained a head injury, I immediately call 112 and avoid moving him/her. | 0.98±0.14 | 0.96±0.19 | 0.01±0.19 | 0.320 |
| 10. In the event of a fall from a height or from a bicycle, I try to lift my unconscious child from where he/she is and take him/her to the hospital as quickly as possible. | 0.58±0.49 | 0.85±0.35 | 0.26±0.52 | <0.001 |
| 11. In cases of falls, such as from a height or from a bicycle, I immediately call 112 and ensure that my child does not move, even if he or she is conscious. | 0.91±0.28 | 0.96±0.19 | 0.04±0.32 | 0.132 |
| 12. In the event of a fall from a height, such as from a bicycle, if the accident area is dangerous and my child needs to be moved, I carry my child upright by dragging him/her without shaking her. | 0.67±0.47 | 0.83±0.37 | 0.15±0.41 | <0.001 |
| 13. If my child falls from a height or from a bicycle, and there is danger at the accident site requiring that my child be carried, I ensure the head-neck-body axis is maintained during transport and remains immobilized until the call arrives. | 0.95±0.21 | 0.99±0.09 | 0.03±0.24 | 0.103 |

∗∗: Paired t-test, ∗: Statistically significant p<0.05

Discussion

Although awareness and prevention efforts aimed at reducing head trauma have increased in recent years, it remains one of the major health problems among children.³ Parents, as the primary caregivers responsible for creating a safe environment and responding to injuries, play a critical role in both prevention and early intervention.¹³ However, most parents are unaware of their need for first-aid training until they are invited to attend structured educational programs, which are often organized and led by nurses. In this study, a pediatric nurse-led training program focusing on first-aid for

pediatric head trauma was implemented, and its impact on parents' knowledge levels was evaluated.

When children experience accidents, their parents are typically the closest caregivers. Therefore, it is crucial for parents to possess a high level of basic first-aid knowledge and practical skills to prevent mortality and morbidity. In the study, 94.1% of the participating parents were mothers. This finding is consistent with several studies in the literature^{10,11,14,15} which indicate that mothers are the primary caregivers in most societies. These results underscore the importance of prioritizing mothers in accident-prevention initiatives and in the development of first-aid training programs.

Consistent with Hughes et al.¹⁶ this study found that short-distance falls, including falls from couches, beds, or a standing position, were the primary cause of head trauma in children. Although rates varied across studies, falls were consistently identified as the most common cause of head trauma, particularly in children aged 0-4 years.^{2,17,18} The mean age of the children who sustained head trauma in the study was consistent with previous research.¹⁹⁻²¹ The higher prevalence in young children is likely attributable to their increased curiosity, incomplete physical and cognitive development, and inadequate parental supervision. Furthermore, anatomical factors such as larger head-to-body ratios, incomplete brain myelination, and open cranial sutures increase their susceptibility to head trauma.^{22,23} From a clinical and public health perspective, these results highlight the urgent need for targeted fall prevention interventions and parental supervision strategies, particularly for toddlers and preschool-aged children. In addition, the higher rate of head trauma among boys than among girls, as observed in this study, is consistent with findings in the literature.^{3,17,20,21,24} The higher frequency of head trauma in boys may be attributed to parents' greater provision of preventive care to girls and to boys' greater propensity for risky, physically active play.

It is important for parents to be familiar with quick and effective first-aid practices to ensure their children's safety. However, many studies have shown that parents' first-aid knowledge and practices are inadequate.²⁵⁻³¹ Compared to these studies, the majority of parents in our study reported a lack of knowledge about first-aid for head injuries, which is not surprising. These findings highlight the need for targeted first-aid training programs specifically tailored to pediatric head trauma. In addition, head trauma is a leading cause of emergency department visits among young children.^{17,32} In the study, fewer than half of the parents of children with head trauma sought emergency care. This may be because parents fail to recognize head injury symptoms or perceive them as minor.

The literature shows that parents' first-aid knowledge and practice levels can be improved through training.^{10,33} Comparison of mean scores before and after first-aid training showed a statistically significant improvement, indicating that the training was effective. This finding is consistent with El Seifi et al.²⁴ who found a significant increase in mothers' first-aid knowledge after training, and with Cetinkaya and Odabasi¹⁰ who reported similar improvements in parents' understanding of pediatric burns. The post-training improvement in knowledge scores demonstrates that even brief, structured education can yield meaningful learning gains. The present study extends these findings by focusing specifically on pediatric head trauma—a critical yet understudied area—and demonstrating that a 15-minute nurse-led poster-based

session can significantly enhance caregiver knowledge from a practical standpoint, such brief interventions are feasible to integrate into routine pediatric visits, immunization clinics, or community health programs.

Clinical findings of head trauma have been described in the literature.² Particularly in children who have experienced an accident affecting the head and neck region, signs such as loss of consciousness, swelling of the head, bruising under the eyes and behind the ears, or sounds such as crying or moaning may indicate head trauma.^{2,34,35} In the study, parents' mean scores on the 1st, 3rd, 4th, and 6th post-test items increased, and these increases were statistically significant. Increased parental clinical signs of head trauma is crucial for early recognition and intervention of head injuries.

Immobilizing children who have sustained a head injury, without moving their heads, is crucial to maintaining their breathing and ensuring their survival, because head trauma can be associated with fatal TBI.^{36,37} Therefore, administering appropriate first-aid in cases of head trauma is crucial for the child's health and survival. Statistically significant differences between the pre-test and post-test mean scores, particularly for items 7, 10, and 12 in Table 3, have important implications for addressing potential misconceptions held by parents. Increasing parents' knowledge and awareness regarding head trauma is a critical responsibility for preventing morbidity and mortality.

Study Limitations

This study has several limitations that should be considered when interpreting the findings. First, the absence of a control group limits the ability to attribute improvements solely to the training intervention. Second, the study assessed only short-term knowledge gains; no follow-up was conducted to evaluate knowledge retention or real-life application. Third, the sample was drawn from a single primary healthcare center in Türkiye using convenience sampling, which may limit the generalizability of the findings to other populations or settings. Additionally, the questionnaire used to measure knowledge was developed by the researchers; although content validity and reliability were assessed, psychometric properties, such as construct validity, were not fully established.

Conclusion

This study demonstrated that a brief, educational intervention improved parents' knowledge of first-aid for pediatric head trauma. Strengthening such community-based educational models can contribute to early recognition, appropriate management, and ultimately, a reduction in preventable morbidity and mortality. Future programs should combine theoretical and hands-on training to reinforce learning

and address persistent knowledge gaps. Integrating such interventions into primary healthcare services and parental education will enhance community preparedness and empower parents in responding effectively to pediatric emergencies.

Ethics

Ethics Committee Approval: Ethics committee approval for this research was obtained from the Hitit University Non-Interventional Research Ethics Committee (approval no: 2023-17, date: 01.11.2023).

Informed Consent: Consent was obtained from parents who presented to the primary health care center for reasons such as vaccination or treatment, to ascertain their willingness to participate in the study.

Footnotes

Authorship Contributions

Surgical and Medical Practises: S.S., Concept: S.S., Z.Ü., Design: S.S., Data Collection or Processing: S.S., H.D., Analysis or Interpretation: S.S., Literature Search: S.S., H.D., Writing: S.S., H.D., Z.Ü.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

References

1. Fulkerson DH, White IK, Rees JM, Baumanis MM, Smith JL, et al. Analysis of long-term (median 10.5 years) outcomes in children presenting with traumatic brain injury and an initial Glasgow Coma scale score of 3 or 4. *J Neurosurg Pediatr.* 2015;16:410-9.
2. Gelineau-Morel RN, Zinkus TP, Le Pichon JB. Pediatric head trauma: a review and update. *Pediatr Rev.* 2019;40:468-81.
3. Black LI, Zammit EP, Hoffman HJ, Li CM. Parental report of significant head injuries in children aged 3-17 years: United States, 2016. *NCHS Data Brief.* 2018:1-8.
4. Kord Z, Alimohammadi N, Jafari Mianaei S, Riaz A, Zarasvand B. Clinical guideline for nursing care of children with head trauma (HT): study protocol for a sequential exploratory mixed-method study. *Pediatric Health Med Ther.* 2020;11:269-75.
5. Araki T, Yokota H, Morita A. Pediatric traumatic brain injury: characteristic features, diagnosis, and management. *Neurol Med Chir (Tokyo).* 2017;57:82-93.
6. Centers for Disease Control and Prevention (CDC). Web-based injury statistics query and reporting system (WISQARS) [Internet]. Accessed: June 21, 2025. Available at: <https://wisqars.cdc.gov/fatal-leading>
7. Trefan L, Houston R, Pearson G, Edwards R, Hyde P, et al. Epidemiology of children with head injury: a national overview. *Arch Dis Child.* 2016;101:527-32.
8. Choe MC, Gregory AJ, Haegerich TM. What pediatricians need to know about the CDC Guideline on the diagnosis and management of mTBI. *Front Pediatr.* 2018;6:249.
9. Kukreti V, Mohseni-Bod H, Drake J. Management of raised intracranial pressure in children with traumatic brain injury. *J Pediatr Neurosci.* 2014;9:207-15.
10. Cetinkaya F, Odabasi G. The effect of the training on parents' knowledge level regarding first aid in pediatric burns. *Int J Caring Sci.* 2021;14:1732-9.
11. Wani JI, Almushayt NO, Abbag WF, Buhran LA, Nadeem M. Pediatric first aid, trauma knowledge, and attitude among parents and general population in Aseer region, Southern Saudi Arabia. *SAGE Open Med.* 2022;10:20503121221126762.
12. Zideman DA, Singletary EM, Borra V, Cassan P, Cimpoesu CD, et al. European Resuscitation Council Guidelines 2021: first aid. *Resuscitation.* 2021;161:270-90.
13. Kavurmaci M, Kucukoglu S. Determination of the pre-hospital practices performed for children with burn injuries. *JCAM.* 2015;6:806-10.
14. Alqahtani MAA, Alshahrani MMA, Alfayi NA, Alshahrani MMA, Algahtani AM, et al. Pattern of accidents in children less than 14 years in Abha City, Kingdom of Saudi Arabia. *Int J Med Res Health Sci.* 2018;7:73-7.
15. Choi Y, Ahn HY. Developing and evaluating a mobile-based parental education program for preventing unintentional injuries in early childhood: a randomized controlled trial. *Asian Nurs Res (Korean Soc Nurs Sci).* 2021;15:329-36.
16. Hughes J, Maguire S, Jones M, Theobald P, Kemp A. Biomechanical characteristics of head injuries from falls in children younger than 48 months. *Arch Dis Child.* 2016;101:310-5.
17. Ahmad I, Raza MH, Qasim A, Ahmad S, Abbas E, et al. Head injury due to fall from heights in pediatric population of a middle resource country. *Pak J of Neurol Surg.* 2023;27:430-6.
18. Bozan K, Algin A, Özdemir S, Erdoğan M, Koyuncu N, et al. Characteristics of minor head trauma in toddlers. *J Exp Clin Med.* 2021;38:516-20.
19. Fekih Hassen A, Zayani MC, Friaa M, Trifa M, Ben Khalifa S. Épidémiologie du traumatisme crânien à l'hôpital d'enfants de Tunis au cours de l'année 2007 [Epidemiology of pediatric traumatic brain injury at the children's hospital of Tunisia, 2007]. *Tunis Med.* 2012;90:25-30.
20. Kessely YC, Sobdjolbo O, Njesada N, Toudjingar FG, Ngaringuem O, et al. Pediatric traumatic brain injury in Chad: about 256 cases. *Egyptian Journal of Neurosurgery.* 2024;39:1-7.
21. Long JC, Dalton S, Arnolda G, Ting HP, Molloy CJ, et al. Guideline adherence in the management of head injury in Australian children: a population-based sample survey. *PLoS One.* 2020;15:e0228715.
22. Hardeid P, Davey J, Dattani N, Gilbert R; Working Group of the Research and Policy Directorate of the Royal College of Paediatrics and Child Health. Child deaths due to injury in the four UK countries: a time trends study from 1980 to 2010. *PLoS One.* 2013;8:e68323.
23. Hawley C, Wilson J, Hickson C, Mills S, Ekeocha S, et al. Epidemiology of paediatric minor head injury: comparison of injury characteristics with indices of multiple deprivation. *Injury.* 2013;44:1855-61.
24. El Seifi OS, Mortada EM, Abdo NM. Effect of community-based intervention on knowledge, attitude, and self-efficacy toward home injuries among Egyptian rural mothers having preschool children. *PLoS One.* 2018;13:e0198964.

25. Al-Bshri SA, Jahan S. Prevalence of home related injuries among children under 5 years old and practice of mothers toward first aid in Buraidah, Qassim. *J Family Med Prim Care*. 2021;10:1234-40.
26. Al-Johani AAS, Sabor S, Aldubai SAR. Knowledge and practice of first aid among parents attending primary health care centers in Madinah City, Saudi Arabia, a cross sectional study. *J Family Med Prim Care*. 2018;7:380-8.
27. Bánfai B, Deutsch K, Pék E, Radnai B, Betlehem F. Accident prevention and first aid knowledge among preschool children's parents. *Kontakt*. 2015;17:e42-7.
28. Míguez-Navarro C, Ponce-Salas B, Guerrero-Márquez G, Lorente-Romero J, Caballero-Grolimund E, et al. The knowledge of and attitudes toward first aid and cardiopulmonary resuscitation among parents. *J Pediatr Nurs*. 2018;42:e91-6.
29. Dirimeşe E, Taşdemir N, Çelik S, Gümüş M, Akalın TC. Examining first-aid knowledge level of mothers living in rural areas and factors that affect this. *Gazi Med J*. 2020;31:153-8.
30. Elmas EG, Durna Z, Akin S. Assessment of knowledge and attitudes of mothers with children about first aid practices for home accidents and security precautions. *J Acad Res Nurs*. 2020;6:267-79.
31. Bassam SEA. Evaluate maternal knowledge and attitude regarding first aid among their children in Buraidah City, Saudi Arabia Kingdom (KSA). *Med Arch*. 2022;76:164-9.
32. Kuppermann N, Holmes JF, Dayan PS, Hoyle JD Jr, Atabaki SM, et al. Identification of children at very low risk of clinically-important brain injuries after head trauma: a prospective cohort study. *Lancet*. 2009;374:1160-70.
33. Feng Y, Ma X, Zhang Q, Jiang R, Lu J, et al. Effectiveness of WeChat-group-based parental health education in preventing unintentional injuries among children aged 0-3: randomized controlled trial in Shanghai. *BMC Public Health*. 2022;22:2086.
34. Lee LK, Monroe D, Bachman MC, Glass TF, Mahajan PV, et al. Isolated loss of consciousness in children with minor blunt head trauma. *JAMA Pediatr*. 2014;168:837-43.
35. Schutzman S. Minor blunt head trauma in infants and young children (<2 years): clinical features and evaluation [Internet]. UpToDate. 2024. Accessed: October 29, 2024. Available at: <https://www.uptodate.com/contents/minor-blunt-head-trauma-in-infants-and-young-children-less-than2-years-clinical-features-and-evaluation>
36. Drake SA, Holcomb JB, Yang Y, Thetford C, Myers L, et al. Establishing a regional pediatric trauma preventable/potentially preventable death rate. *Pediatr Surg Int*. 2020;36:179-89.
37. Theodorou CM, Galganski LA, Jurkovich GJ, Farmer DL, Hirose S, et al. Causes of early mortality in pediatric trauma patients. *J Trauma Acute Care Surg*. 2021;90:574-81.



Clinico-etiological Profile of Poisoning in Children and Impact of Counselling on Child Care and Safety Practices - A Prospective Study from North India

Çocuklarda Zehirlenmelerin Klinik-etiyolojik Profili ve Danışmanlığın Çocuk Bakımı ile Güvenlik Uygulamaları Üzerindeki Etkisi - Kuzey Hindistan'dan İleriye Yönelik Bir Çalışma

Shikhar Gupta¹, Urmila Jhamb², Deepak Kumar¹, Pallavi Pallavi¹

¹University of Delhi Maulana Azad Medical College, Lok Nayak Hospital, Department of Pediatrics, New Delhi, India

²Santosh Medical College and Hospital, Department of Pediatrics, Ghaziabad, India

Abstract

Introduction: Childhood poisoning, resulting from exposure to various substances through ingestion, inhalation, or contact, is a major global health concern. In India, the increased availability of household, agricultural, industrial, and pharmaceutical chemicals has led to an increased incidence of accidental poisonings among children aged 1-5 years. This study examines the prevalence, types, and outcomes of childhood poisoning in India, highlighting the role of sociodemographic factors and parental behaviors. Hospital data underscore the need for improved education and safety practices, including effective counseling and strategies to support behavioral change, to reduce incidents and improve long-term outcomes.

Methods: This prospective study was conducted in a tertiary-care hospital in North India from December 2022 to August 2023 to analyze the burden and types of childhood poisoning and to assess the influence of sociodemographic factors using the modified Kuppuswamy scale (2023). Secondary outcomes included clinical outcomes and post-counseling behavioral changes, assessed at the two-month follow-up. Follow-up, conducted through telephonic consultations, evaluated late sequelae, repeat poisonings, and changes in safety practices.

Results: One hundred and two pediatric poisoning cases were enrolled, representing 1.53% of all pediatric emergencies (n=6630). Most cases occurred in children aged 1-5 years (74.7%, n=76), predominantly male (66.7%, n=68), with higher incidence in metropolitan areas (62.7%, n=64) and in lower socioeconomic groups (81.4%, n=83). Household cleaning agents (40.2%, n=41) and hydrocarbons (23.5%, n=24) were the leading causes, reflecting

Öz

Giriş: Çocukluk çağı zehirlenmeleri; yutma, soluma veya temas yoluyla maddelere maruz kalma sonucu ortaya çıkan önemli bir küresel halk sağlığı sorunudur. Hindistan'da evsel, tarımsal, endüstriyel ve farmasötik kimyasalların artan erişilebilirliği, 1-5 yaş arası çocuklarda kazara zehirlenmeleri artırmıştır. Bu çalışma, Hindistan'da çocukluk çağı zehirlenmelerinin prevalansını, türlerini ve sonuçlarını inceleyerek sosyodemografik faktörler ve ebeveyn davranışlarının rolünü vurgulamaktadır. Hastane verileri, etkili danışmanlık ve davranış değişikliği yoluyla eğitim ve güvenlik uygulamalarının güçlendirilmesi gerekliliğini ortaya koymaktadır.

Yöntemler: Aralık 2022-Ağustos 2023 tarihleri arasında Kuzey Hindistan'da bir üçüncü basamak hastanede yürütülen bu ileriye yönelik çalışmada, çocukluk çağı zehirlenmelerinin yükü ve türleri ile sosyodemografik faktörlerin etkisi 2023 modifiye Kuppuswamy ölçeği kullanılarak değerlendirildi. İkincil sonuçlar; klinik seyir ve iki aylık takip sonrası danışmanlıkla oluşan davranış değişikliklerini içerdi. Takipte geç sekeller, tekrarlayan zehirlenmeler ve güvenlik uygulamalarındaki değişiklikler telefon görüşmeleriyle değerlendirildi.

Bulgular: Toplam 102 pediyatrik zehirlenme olgusu çalışmaya alındı ve tüm pediyatrik acil başvurularının %1,53'ünü (n=6630) oluşturdu. Olguların çoğu 1-5 yaş grubunda (%74,7; n=76), erkeklerde (%66,7; n=68) ve metropoliten bölgelerde (%62,7; n=64) görüldü; düşük sosyoekonomik gruplarda daha yüksekti (%81,4; n=83). En sık nedenler evsel temizlik maddeleri (%40,2; n=41) ve hidrokarbonları (%23,5; n=24); bu durum kerosen zehirlenmesindeki azalmayı göstermektedir. Asit bazlı korozif temizleyiciler yaygındı. Beş yaş üzeri çocuklar, yaşlı büyük kardeşi olanlar ve geniş ailede yaşayanlarda

Address for Correspondence/Yazışma Adresi: Prof. MD, Deepak Kumar, University of Delhi Maulana Azad Medical College, Lok Nayak Hospital, Department of Pediatrics, New Delhi, India

E-mail: deepakk70@gmail.com **ORCID ID:** orcid.org/0000-0002-3380-7009

Received/Geliş Tarihi: 09.09.2025 **Accepted/Kabul Tarihi:** 25.12.2025 **Pub:** 16.02.2026 **Publication Date/Yayınlanma Tarihi:** 01.04.2026

Cite this article as: Gupta S, Jhamb U, Kumar D, Pallavi P. Clinico-etiological profile of poisoning in children and impact of counselling on child care and safety practices - a prospective study from North India. J Pediatr Emerg Intensive Care Med. 2026;13(1):32-8



©Copyright 2026 The Author(s). Published by Galenos Publishing House on behalf of Society of Pediatric Emergency and Intensive Care Medicine. This is an open access article under the Creative Commons Attribution-Attribution-NonCommercial 4.0 (CC BY-NC 4.0) International License.

Abstract

a shift from the earlier predominance of kerosene. Corrosive cleaners—mainly acid-based—were common. Being older than five years, having older siblings, and living in a joint family were associated with a lower incidence of poisoning. Outcomes were favorable in most cases, with 84.3% successfully discharged; two deaths occurred due to corrosive poisoning. Follow-up showed no repeat incidents, and parental counseling significantly improved storage practices.

Conclusion: The study demonstrates a changing pattern in childhood poisoning, with corrosive agents emerging as the most common cause and kerosene poisoning declining. Addressing household risks, strengthening parental education, and improving healthcare systems are essential, with counseling playing a pivotal preventive role.

Keywords: Toxicology, clinical profile, poisoning, pica, child safety practices

Öz

zehirlenme insidansı daha düşüktü. Olguların %84,3'ü başarıyla taburcu edildi; korozif zehirlenme nedeniyle iki ölüm görüldü. Takipte tekrarlayan zehirlenme saptanmadı ve ebeveyn danışmanlığı depolama uygulamalarını belirgin şekilde iyileştirdi.

Sonuç: Çalışma, çocukluk çağı zehirlenmelerinde korozif maddelerin öne çıktığını ve kerosen zehirlenmelerinin azaldığını göstermektedir. Ev içi risklerin azaltılması, ebeveyn eğitiminin güçlendirilmesi ve sağlık sistemlerinin geliştirilmesi kritik olup, danışmanlık önlemede kilit rol oynamaktadır.

Anahtar Kelimeler: Toksikoloji, klinik profil, zehirlenme, pika, çocuk güvenliği uygulamaları

Introduction

Poisoning refers to injury resulting from exposure to an exogenous substance that causes cellular damage or cell death. This exposure can occur through ingestion, inhalation, injection, or direct contact. The severity and outcome of poisoning in children depend on several interrelated factors, including the type, amount, and form of the poison, the route of exposure, the child's age and nutritional status, the presence of other toxins, and concurrent diseases or injuries.¹

In India, a developing nation, the use of various household, agricultural, industrial, and pharmaceutical chemicals has surged. The presence of these in households and surrounding areas contributes to an increased incidence of accidental poisoning among children, who are naturally curious.² The vast majority of cases belong to children aged 1-5 years.^{3,4} The common types of poisoning observed in them include kerosene (hydrocarbons), household cleaning agents (corrosives), turpentine, medications, insecticides, among others.

An analysis of data across multiple regions of India indicates that hydrocarbon poisoning, particularly kerosene, is the predominant type of poisoning in the country.^{3,5} The incidence of hydrocarbon poisoning is notably higher in rural areas compared to urban areas. Additionally, rural regions experience higher rates of snake bites, ingestion of poisonous plants, and exposure to unknown substances. Over time, the nature of these available agents has changed because of lifestyle shifts and regional development, resulting in altered poisoning patterns.

Across the globe, thousands of children are brought to the hospital with cases of accidental poisoning that could have been avoided with better education and preparedness.^{6,9}

Parents' behavior regarding childcare and safety practices also plays an important role in determining the causes and incidence of accidental poisoning among children.

This study examined the prevalence and types of childhood poisoning and the influence of sociodemographic factors on these events. The study also assessed outcomes at presentation and at two months' follow-up, focusing on long-term effects, repeat incidents, and changes in parents' safety behaviors after counseling provided to all parents during hospital stays about safe storage practices for poisonous substances.

Materials and Methods

A prospective observational study of poisoning among children under 12 years of age was conducted in the clinic of pediatrics at a tertiary-care hospital in North India from December 2022 to August 2023. The study commenced after obtaining approval from the Maulana Azad Medical College and Associated Hospital Institutional Ethics Committee (approval no: F1/IEC/MAMC/MD/MS 92/04/2022 No.371, date: 29.08.2022). This study investigated the burden and types of childhood poisoning and examined the influence of sociodemographic factors. It addresses child-specific factors (e.g., pica), parental dynamics (e.g., educational status), family characteristics (e.g., family type, number of children, crowding, and urban or rural setting), and the use of home child-proofing measures. Details of the poison encompass type, quantity, accessibility, and packaging, whereas ingestion events are categorized according to how they were discovered. Post-ingestion symptoms and parents' actions, including initial steps taken and presentation to the hospital, were analyzed. Hospital outcomes, previous poisoning episodes, and nutritional status were also evaluated.

At discharge, the parents of the enrolled patients were counseled on child safety practices, child-proofing, and childcare, including adequate nutrition. A follow-up telephone call was conducted at two months to monitor for delayed effects, recurrent episodes, and behavioral changes in parents or family members. A single investigator collected daily data using a predesigned proforma; the data were then analyzed to characterize the spectrum of poisonings and their outcomes.

At discharge, all parents received a structured counselling session focused on preventing future poisoning episodes. The counselling was delivered in person by the investigator, a pediatric resident, and was supervised by a consultant pediatrician. Each session lasted approximately 15 minutes and followed a standardised checklist consisting of seven domains. Counseling was delivered verbally and supported by simple demonstrations, such as how to lock cabinets, when relevant. The parents were also encouraged to ask questions and seek clarification.

A telephone follow-up at two months after discharge was conducted to enquire about recurrent episodes, changes in the child's behaviour, improvement in pica (if present), and implementation of recommended safety practices at home.

Statistical Analysis

The data collected were entered into an MS Excel sheet and analyzed using descriptive statistics. The categorical responses are expressed as percentages. Continuous data were presented as mean (± 2 standard deviation) for parametric variables and median (interquartile range) for non-parametric variables.

Results

This study spanned from December 2022 to August 2023. Notably, 1.53% (102) of all pediatric emergency admissions (n=6630) were due to poisoning. Most patients were 1-5 years old (74.7%, n=76); males predominated (66.7%, n=68). Urban areas accounted for 62.7% (n=64) of cases, and 84.3% (n=86) of cases were from within the city. Ninety-five incidents (93.2% of the total) occurred in and around the house. Only 6.8% (n=7) of cases were reported outdoors. Corrosive agents were the leading cause of poisoning (40.2%, n=41), followed by hydrocarbons (23.5%, n=24) and drugs (17.6%, n=18). Acid-based toilet cleaners were the most common corrosives, and turpentine was the most common hydrocarbon (Tables 1-3). Pallor was observed in 73.5% (n=75) of patients, while 61.8% (n=63) exhibited pica. Anemia was present in 85.3% (n=87) of the children. Among these, 68 (78.2%) also exhibited pallor, whereas 19 (21.8%) were anemic without pallor. Of the 75 children with pallor,

68 (90.7%) had anemia and 7 (9.3%) did not. The highest incidence of poisoning occurred during the summer (41.2%, n=42) and monsoon (30.4%, n=31) seasons. Corrosive and hydrocarbon poisonings peaked in summer and the monsoon (73%, n=30; 66.6%, n=16, respectively). Drug ingestion (Table 4) spiked in winter (61.1%, n=11), while insecticides (Table 5) and venomous animal bites surged during the monsoon (70%, n=7 and 60%, n=3 respectively).

Among parents, 30.4% (n=31) had only a primary-school education, 45.1% (n=46) had a high-school education, 23.5% (n=24) had graduate degrees, and 1% (n=1) had postgraduate qualifications. Regarding socioeconomic status, 51 (50%) belonged to the lower class, 32 (31.4%) to the upper lower class, and 19 (18.6%) fell into the lower middle class. Thirty-six children (35.3%) were second-born, 27 (26.5%) were first-born, and 25 (24.5%) were third-born. In the majority of cases, two children were at home (37.3%, n=38), followed by three (29.4%, n=30), four (12.7%, n=13), and one (12.7%, n=13). Of the children, 91.2% (n=89) were from nuclear families. Only 5.9% (n=6)

Table 1. Type of poisoning agent

| | Poisoning agent | Number of patients | Percentage |
|---|------------------------------------|--------------------|------------|
| A | Corrosives | 41 | 40.2% |
| B | Hydrocarbons | 24 | 23.5% |
| C | Drugs | 18 | 17.64% |
| D | Insecticides | 10 | 9.86% |
| E | Venomous animal bites ^a | 5 | 4.9% |
| F | Miscellaneous ^b | 4 | 3.9% |
| | Total | 102 | 100% |

^a: Three cases of snake bite by common krait, one snake bite by cobra, and one case of scorpion bite, ^b: One case each of ingestion of camphor, silica powder, clay and soap

Table 2. Type of corrosive agent

| | Type of corrosive | Number | Percentage (out of total) |
|---|---|--------|---------------------------|
| A | Toilet cleaner (hydrochloric acid) | 27 | 26.47% |
| B | Bleach [sodium hypochlorite (alkali)], used for laundry | 7 | 8.86% |
| C | Phenyl (carbolic acid, a weak acid) | 4 | 3.92% |
| D | Caustic soda (sodium hydroxide) | 2 | 1.96% |
| E | Vinegar [acetic acid (weak acid)] | 1 | 0.98% |

Table 3. Type of hydrocarbon

| | Type of hydrocarbon | Number | Percentage (out of total) |
|---|------------------------------------|--------|---------------------------|
| A | Turpentine (paint thinner) | 15 | 14.7% |
| B | Kerosene | 7 | 8.86% |
| C | Machine oil | 1 | 0.98% |
| D | Naphthalene (aromatic hydrocarbon) | 1 | 0.98% |

Table 4. Type of drugs

| | Type of drugs | Number | Percentage (out of total) |
|----------|--|--------|---------------------------|
| A | Belonged to the patient and given in wrong dosage | 10 | 9.86% |
| B | Paracetamol | 3 | 2.94% |
| C | Dextromethorphan | 3 | 2.94% |
| D | Thyroxine | 2 | 1.96% |
| E | Phenytoin | 2 | 1.96% |
| F | Belonged to other family members | 8 | 7.84% |
| G | Other drugs: promethazine, cannabinoid, permethrin, propranolol, aripiprazole, olanzapine, hydrogen peroxide, salicylic acid | 1 each | 0.98% |

Table 5. Type of insecticides and pesticides

| | Type of insecticides and pesticides | Number | Percentage (out of total) |
|----------|---|--------|---------------------------|
| A | Pyrethroid (mosquito repellent liquid) | 6 | 5.9% |
| B | Brodifacoum (anticoagulant rodenticide) | 2 | 1.96% |
| C | Paraquat (weed killer) | 1 | 0.98% |
| D | Organophosphate (insecticide) | 1 | 0.98% |

Table 6. Type of storage containers, appearance, availability and accessibility of agents

| Characteristics Number | Percentage | |
|-----------------------------------|------------|--------|
| Type of storage containers | | |
| Transparent water bottle | 47 | 48.5% |
| Attractive packaging | 16 | 16.5% |
| Soft drink bottles | 14 | 14.4% |
| Medicine bottles | 10 | 10.3% |
| Hazardous marked containers | 10 | 10.3% |
| Appearance | | |
| Colored | 70 | 72.10% |
| Transparent | 27 | 27.90% |
| Availability | | |
| Easy to acquire | 63 | 64.9% |
| Difficult to acquire | 34 | 35.1% |
| Accessibility | | |
| Easy to access | 95 | 98% |
| Out of reach | 2 | 2% |

of children had both parents working, whereas 94.1% (n=96) had one parent working.

The choice of storage containers for toxic agents is crucial to prevent accidental poisoning. Transparent water bottles

were most commonly used (48.5%, n=47), followed by attractive packaging (16.5%, n=16), and empty soft drink bottles (14.4%, n=14). Fewer agents were stored in medicine bottles (10.3%, n=10) or in containers marked as hazardous (10.3%, n=10). The majority of toxic agents, 98% (n=99), were easily accessible to patients because they were within physical reach, clearly visible, and lacked child-resistant packaging, permitting easy opening (Table 6).

In our study, most ingestion events (89.2%, n=91) were promptly observed or otherwise detected by parents, particularly in cases involving corrosives and hydrocarbons, in which symptoms developed rapidly. In a small percentage (8.8%, n=8), children alerted parents to their distress, whereas in 2% (n=2) of cases, children kept the ingestion a secret, which eventually led parents to identify the cause of illness.

Notably, 97.1% (n=99) of events were accidental, while only 2.9% (n=3) were reported as homicidal. In one case, a mother attempted suicide by ingesting an agricultural-grade herbicide (paraquat) herself and by feeding it to her baby. In another case, a mother attempted suicide by ingesting bleach mixed with milk and by feeding it to both her children. After exposure, about half (47.5%, n=46) of the patients induced vomiting at home by parents/caregivers through digital stimulation of the throat, while 52.5% (n=51) took no home-based action. About 58.8% (n=57) arrived within 30 minutes, 20.6% (n=20) at 30 minutes to two hours, and 20.6% (n=20) after more than two hours. Vomiting was the predominant symptom at hospital presentation (67.6%, n=66).

Most patients had a 1-3-day hospital stay (59.8%, n=58), 15.6% (n=15) stayed for 4-7 days, and 11.8% (n=11) were required to stay over seven days while 12.8% (n=12) got discharged on the same day. Pediatric intensive care unit (PICU) stay was required for 11.8% (n=11) of patients. Out of 41 patients with corrosive ingestion, 61% (n=25) underwent upper gastrointestinal endoscopy. Two patients died during treatment, representing a mortality rate of 1.96% (n=2). In both fatal cases, the offending agent was a corrosive toilet cleaner that had been stored in water bottles.

At discharge, parents of enrolled patients were counselled, according to the standardised checklist (Table 7), about child safety practices, child-proofing, and childcare, including proper nourishment. Two months after discharge, 82 of 86 patients were successfully reached by telephone, with only four (4.66%) lost to follow-up. Parents exhibited significant behavioral changes regarding the storage of potentially poisonous agents, with 96.3% (n=94) making efforts to prevent accidental ingestion. No repeated accidental ingestions occurred (Table 8).

Table 7. Standardised counselling checklist

| | | |
|----|-----------------------|---|
| 1. | Secure medications | - Keep meds locked up and out of reach. - Use child-resistant packaging. |
| 2. | Chemical safety | - Store household chemicals in locked cabinets. - Restrict access to cleaning products and agents. - Follow guidelines for disposal. |
| 3. | Child-proofing | - Install safety locks on cabinets. - Secure personal care items. |
| 4. | Education | - Teach children about the dangers of ingesting substances and about their safe handling. - Emphasize that products are not toys. |
| 5. | Emergency information | - Keep poison control number accessible. - Take the child immediately to the nearest hospital. - Do not try to induce vomiting at home. |
| 6. | Supervision | - Keep a close eye on young children. - Be cautious in unfamiliar environments, and monitor during outdoor play. |
| 7. | Proper food storage | - Store food items securely, away from harmful substances. |

Table 8. Attitude changes in parents after counselling

| Attitude changes in parents | Number of cases | Percentage |
|-----------------------------|-----------------|------------|
| Yes | 79 | 96.3% |
| No | 3 | 3.7% |

Discussion

In our study, accidental poisonings accounted for 1.53% of all pediatric emergency admissions, which is similar to the 1.05% reported at our centre in 2009³ and consistent with studies by Jadhav et al.¹⁰, Koh et al.⁶, and other studies across India.^{2,4,9} Most affected children (76.4%) were aged 1-5 years, a trend widely reported in the literature.^{2,5,6,9-11} This age group is more prone to accidental ingestion due to exploratory behaviour and limited awareness. A male predominance (66.7%) was also noted in line with the findings of Brata Ghosh et al.² and Tarvadi et al.¹²

A higher proportion of cases were from metropolitan areas (62.7%) and from lower socioeconomic strata (81.4%), according to the modified Kuppaswamy scale (2023). The World Health Organization World report on child injury prevention reports similar observations, highlighting increased poisoning risks among lower-income groups.¹

Corrosive household cleaners were the most common agents (40.2%), followed by hydrocarbons (Tables 1-3). This represents a shift from earlier studies, including Parekh and Gupta¹³ and our 2009 data, where kerosene dominated. More recent work by Suting et al.⁹ also reports a decline in kerosene ingestion comparable to our findings (6.8%). Turpentine has now replaced kerosene as the predominant hydrocarbon (Table 3). The rise in ingestion of corrosive

cleaners may reflect reduced kerosene use and changes in household practices. Acid-based toilet cleaners accounted for the majority of corrosive ingestions (65.8%), whereas bleach accounted for 17.3% (Table 2). Western studies also report a rise in ingestions of household cleaners, although alkaline agents predominate.^{5,6,11,14}

Hydrocarbons ranked second, with turpentine accounting 62.5% of cases and often linked to painting activities. Pharmaceuticals ranked third among substances involved in unintentional ingestions (17.64%). Paracetamol and dextromethorphan were the most prevalent medications (16.5% each) and were often administered incorrectly. Other drugs (mainly thyroid medication and anti-epileptic drugs) belonging to family members were accidentally ingested (Table 4). These patterns resemble findings from North India and Western countries.^{2,9,13,15,16}

Venomous bites accounted for 4.9% of cases, predominantly snake bites (80%) and scorpion bites (20%), consistent with the species commonly found in Northern India (Table 1). A seasonal rise in poisonings was observed during summer (41.2%) and the monsoon (30.4%), emphasizing the role of environmental factors.

Most incidents (93%) occurred at home, consistent with previous reports.^{1,2,5} Children older than five years experienced fewer episodes, possibly owing to greater awareness. Family dynamics may also play a role, with larger families providing increased supervision.

Anemia was present in 87 children: 68 (78.2%) had pallor and 19 (21.8%) did not. Among 75 children with pallor, 7 (9.3%) were not anemic. Therefore, pallor detected anemia reasonably well but was unreliable in excluding it. Similar patterns are described in populations with mild anemia. The high rates of pica and pallor suggest underlying nutritional deficiencies that may contribute to both anemia and behavioral tendencies. Previous studies have also reported an association between anemia and pica.^{17,18}

Parents with higher levels of education were more likely to adopt child-proofing measures (24.5% of parents), suggesting an association between education and safety awareness.⁸ Storage practices played a major role, with toxic agents commonly stored in transparent bottles (48.5%) or in attractive containers (16.5%). Improper storage occurred in 79.4% of cases, and nearly all agents (98%) were easily accessible. Availability in the community was also high (64.9%). These findings highlight the need to address unsafe storage and accessibility.^{1,2,16}

Nearly half of caregivers attempted to induce vomiting, usually through digital stimulation, indicating persistent knowledge gaps regarding appropriate first aid.

The study assessed patients' treatment and recovery. The PICU admission rate was 11.8%, while mortality was low (2%). A similar study conducted by Brata Ghosh et al.² showed a PICU admission rate of 11.7%, with a mortality rate of 2.7%. A fall in mortality rates has been observed over the last few decades. A mortality rate of 8.9% was reported in a study conducted by Jayashree and Singhi¹⁹ over the period from 1993 to 2008. A mortality rate of 4.4% was reported in a study by Aggarwal et al.²⁰ during 2010-13. At discharge, detailed discussions with parents led to significant behavioral changes. Parents have become more cautious about children's access to household cleaning agents and have switched to safer alternatives, ensuring that hazardous substances are kept out of reach and are not stored in improper containers. The study implies that sources like the mass media can spread important information to a larger population and can help people learn safe storage practices, thereby reducing childhood poisoning. This collective effort can substantially decrease poisoning incidents, creating a safer environment for children.

Study Limitations

This study was conducted in a single tertiary-care hospital with a small sample size, which may limit the generalizability of the findings. Although the hospital receives children from many states and has a varied case mix referral bias is likely because more severe cases are typically referred to tertiary centers. The results may therefore differ from those seen in primary or district-level facilities. Larger multicenter studies in the future would help confirm and strengthen these findings.

Conclusion

This study examines childhood poisoning incidents, identifying accidental poisoning as the cause in the majority of cases. Household substances, most commonly toilet cleaners, are frequent agents of poisoning, and hydrocarbon poisonings have shifted from kerosene to substances such as turpentine oil. Seasonal patterns and family dynamics significantly influence poisoning incidents. Educational initiatives demonstrate positive outcomes, emphasizing the importance of targeted interventions and improved storage practices, thereby creating a safer environment for children.

Ethics

Ethics Committee Approval: The study commenced after obtaining approval from the Maulana Azad Medical College and Associated Hospital Institutional Ethics Committee (approval no: F.1/IEC/MAMC/MD/MS 92/04/2022/No.371, date: 29.08.2022).

Informed Consent: A prospective observational study.

Footnotes

Authorship Contributions

Concept: S.G., U.J., P.P., Design: S.G., U.J., P.P., Data Collection or Processing: S.G., D.K., Analysis or Interpretation: U.J., D.K., P.P., Literature Search: S.G., D.K., Writing: S.G., U.J., D.K., P.P.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

References

1. Peden M, Oyegbite K, Ozanne-Smith J, Hyder AA, Branche C, et al. World report on child injury prevention. Geneva: World Health Organization; 2008.
2. Brata Ghosh V, Jhamb U, Singhal R, Krishnan R. Common childhood poisonings and their outcome in a tertiary care center in Delhi. *Indian J Pediatr.* 2013;80:516-8.
3. Saikia D, Sharma RK, Janardhan KV. Clinical profile of poisoning due to various poisons in children of age 0-12 years. *J Family Med Prim Care.* 2020;9:2291-6.
4. Das Adhikari D, Das S, Winston A B, Vazhudhi K, Kumar A, et al. A retrospective study on non-drug related poisoning in the community among children from south India. *Hosp Pract (1995).* 2017;45:39-45.
5. McKenzie LB, Ahir N, Stolz U, Nelson NG. Household cleaning product-related injuries treated in US emergency departments in 1990-2006. *Pediatrics.* 2010;126:509-16.
6. Koh SH, Tan KHB, Ganapathy S. Epidemiology of paediatric poisoning presenting to a children's emergency department in Singapore over a five-year period. *Singapore Med J.* 2018;59:247-50.
7. Salman H, Salman Z, Akçam M. Childhood poisoning during the COVID-19 pandemic. *Turk Arch Pediatr.* 2023;58:268-73.
8. Moberg ME, Hamilton EB, Zeng SM, Bryazka D, Zhao JT, et al. Global, regional, and national mortality due to unintentional carbon monoxide poisoning, 2000-2021: results from the Global Burden of Disease Study 2021. *The Lancet Public Health.* 2023;8:e839-49.
9. Suting E, Bhaskar V, Batra P. Changing epidemiology of poisoning in children: a retrospective study from a tertiary care center in New Delhi, India. *Indian J Public Health.* 2021;65:400-2.
10. Jadhav S, Rathi S, B B, Kondekar S. Clinical profile of poisoning in children: a hospital based study. *Int J Contemp Pediatr.* 2016;3:709-12.
11. Anderson M, Hawkins L, Eddleston M, Thompson JP, Vale JA, et al. Severe and fatal pharmaceutical poisoning in young children in the UK. *Arch Dis Child.* 2016;101:653-6.
12. Tarvadi PV, Bakkannavar SM, Palimar V, Kumar GP, Shetty M, et al. Gender differences in childhood poisoning. *Journal of Health and Allied Sciences NU.* 2013;3:69-72.
13. Parekh U, Gupta S. Kerosene-a toddler's sin: a five years study at tertiary care hospital in Western India. *J Forensic Leg Med.* 2017;47:24-8.
14. Mbeledogu CN, Cecil EV, Millett C, Saxena S. Hospital admissions for unintentional poisoning in preschool children in England; 2000-2011. *Arch Dis Child.* 2015;100:180-2.

15. Sarker AK, Ghosh S, Barik K. A study of accidental poisoning (in children) in a rural medical college hospital of West Bengal. *Indian J Public Health.* 1990;34:159-62.
16. Meyer S, Eddleston M, Bailey B, Desel H, Gottschling S, et al. Unintentional household poisoning in children. *Klin Padiatr.* 2007;219:254-70.
17. Ganesan PR, Vasauskas AA. The association between pica and iron-deficiency anemia: a scoping review. *Cureus.* 2023;15:e37904.
18. Leung AKC, Lam JM, Wong AHC, Hon KL, Li X. Iron deficiency anemia: an updated review. *Curr Pediatr Rev.* 2024;20:339-56.
19. Jayashree M, Singhi S. Changing trends and predictors of outcome in patients with acute poisoning admitted to the intensive care. *J Trop Pediatr.* 2011;57:340-6.
20. Aggarwal B, Rana SK, Chhavi N. Pattern of poisoning in children, an experience from a teaching hospital in Northern India. *JK Science.* 2014;16:174-8.



Pediatric Acute Liver Failure: Etiologies, Intensive Care Management, and Prognostic Trends in a Tertiary Center

Üçüncü Basamak Bir Merkezde Pediyatrik Akut Karaciğer Yetmezliği: Etiyoloji, Yoğun Bakım Yaklaşımı ve Prognoz

© Fulden Aycan¹, © Tanıl Kendirli¹, © Emrah Gün¹, © Edin Botan¹, © Zarife Kuloğlu², © Ceyda Tuna Kırsaçlıoğlu², © Meltem Koloğlu³, © Beyza Doğanay Erdoğan⁴, © Suat Fitöz⁵, © Erdal İnce⁶, © Deniz Balcı⁷, © Aydan Kansu²

¹Ankara University Faculty of Medicine, Department of Pediatric Critical Care Medicine, Ankara, Türkiye

²Ankara University Faculty of Medicine, Department of Pediatric Gastroenterology, Hepatology, and Nutrition, Ankara, Türkiye

³Ankara University Faculty of Medicine, Department of Pediatric Surgery, Ankara, Türkiye

⁴Ankara University Faculty of Medicine, Department of Biostatistics, Ankara, Türkiye

⁵Ankara University Faculty of Medicine, Department of Pediatric Radiology, Ankara, Türkiye

⁶Ankara University Faculty of Medicine, Department of Pediatric Infectious Diseases, Ankara, Türkiye

⁷Ankara University Faculty of Medicine, Department of General Surgery, Ankara, Türkiye

Abstract

Introduction: Pediatric acute liver failure (PALF) is a life-threatening multisystem disorder characterized by rapid hepatic dysfunction. This study aimed to describe the etiologies, intensive care management, and outcomes of children with PALF admitted to a tertiary pediatric intensive care unit.

Methods: We retrospectively reviewed 53 children with PALF admitted to our pediatric intensive care unit between January 2014 and December 2019. Demographic characteristics, etiology, intensive care interventions, and clinical outcomes were analyzed.

Results: Toxic or drug-induced causes (43.4%) and indeterminate etiologies (32.1%) were most frequent. Twenty patients (37.7%) required invasive mechanical ventilation, 22 (41.5%) underwent plasma exchange, 11 (20.8%) received continuous renal replacement therapy, and 7 (13.2%) underwent liver transplantation. The mean pediatric intensive care unit stay was 7.4±9.0 days. Patients with toxic/drug-induced PALF required fewer interventions and had lower sepsis rates than those with other etiologies (p<0.01).

Conclusion: Early recognition and comprehensive supportive care improve outcomes in children with PALF. Toxic or drug-induced PALF is associated with a milder clinical course. Continuous assessment of prognostic indicators is essential to guide management and decisions regarding liver transplantation.

Öz

Giriş: Pediyatrik akut karaciğer yetmezliği (PAKY), karaciğer fonksiyonlarının kısa sürede yerine getirilememesi sonucu gelişen, birden fazla organ sistemini etkileyebilen ve yaşamı ciddi biçimde tehdit eden bir hastalık tablosudur. Bu çalışmada, üçüncü basamak bir çocuk yoğun bakım ünitesine yatırılan PAKY tanılı çocukların etiyolojik dağılımları, yoğun bakım sürecindeki tedavileri ve klinik sonuçlarının değerlendirilmesi amaçlanmıştır.

Yöntemler: Ocak 2014 ile Aralık 2019 tarihleri arasında çocuk yoğun bakım ünitesine kabul edilen 53 PAKY tanılı çocuk geriye dönük olarak incelendi. Hastaların demografik özellikleri, hastalığa yol açan nedenler, uygulanan yoğun bakım tedavileri ve klinik sonuçları değerlendirildi.

Bulgular: En sık saptanan nedenler zehirlenme veya ilaca bağlı etiyolojiler (%43,4) ile nedeni belirlenemeyen olgular (%32,1) idi. Hastaların 20'sinde (%37,7) invaziv mekanik ventilasyon gereksinimi gelişti, 22'sine (%41,5) plazma değişimi uygulandı, 11'i (%20,8) sürekli böbrek destek tedavisi aldı ve 7 hastaya (%13,2) karaciğer nakli yapıldı. Çocuk yoğun bakım ünitesinde ortalama yatış süresi 7,4±9,0 gün olarak saptandı. Zehirlenme veya ilaca bağlı PAKY olgularında, diğer nedenlere bağlı olgulara kıyasla daha az yoğun bakım girişimi uygulandığı ve enfeksiyon gelişme oranlarının daha düşük olduğu görüldü (p<0,01).

Address for Correspondence/Yazışma Adresi: Fulden Aycan, MD, Ankara University Faculty of Medicine, Department of Pediatric Critical Care Medicine, Ankara, Türkiye

E-mail: fulden.aycann@gmail.com **ORCID ID:** orcid.org/0000-0001-6644-127X

Received/Geliş Tarihi: 24.07.2025 **Accepted/Kabul Tarihi:** 30.12.2025 **Publ. Date/Yayınlanma Tarihi:** 01.04.2026

Cite this article as: Aycan F, Kendirli T, Gün E, Botan E, Kuloğlu Z, et al. Pediatric acute liver failure: etiologies, intensive care management, and prognostic trends in a tertiary center. J Pediatr Emerg Intensive Care Med. 2026;13(1):39-46



Abstract

Keywords: Pediatric acute liver failure, intensive care, prognosis, liver transplantation, plasma exchange

Öz

Sonuç: PAKY tanılı çocuklarda erken tanı ve etkin destekleyici tedavi, klinik sonuçların iyileştirilmesinde belirleyici rol oynamaktadır. Zehirlenme veya ilaca bağlı PAKY olguları genellikle daha hafif bir klinik seyir göstermektedir. İzlem sürecinde hastalığın gidişatını gösteren bulguların düzenli olarak değerlendirilmesi, karaciğer nakli gereksiniminin zamanında belirlenmesi açısından büyük önem taşımaktadır.

Anahtar Kelimeler: Pediyatrik akut karaciğer yetmezliği, çocuk yoğun bakım, hastalık gidişatı, karaciğer nakli, plazma değişimi

Introduction

Pediatric acute liver failure (PALF) is a potentially life-threatening condition in previously healthy children due to its rapidly progressive course. The PALF study group defines ALF by the following criteria: no prior evidence of chronic liver disease; biochemical markers of acute liver injury or coagulopathy; and encephalopathy with a prothrombin time (PT) >15 seconds or international normalized ratio (INR) >1.5 not correctable by vitamin K, or PT >20 seconds or INR >2 regardless of encephalopathy.¹ PALF represents one of the most challenging critical illnesses in pediatric patients, owing to its association with severe multisystem organ failure, unpredictable complications, and the need for urgent decisions about emergent liver transplantation (LT).²

The clinical course of PALF may be influenced by age, geographic location, underlying etiology, and genetic background. PALF is most frequently observed in neonates and infants, followed by teenagers.^{1,3,4} In neonates, liver failure is commonly caused by immunological, viral, or hematological etiologies, whereas in teenagers it is most commonly due to drug-induced injury.^{1,3} However, in a significant proportion of cases, the underlying cause remains unidentified.^{1,5-8} Currently, no standardized method exists to grade the severity of PALF in children for either research or clinical practice.⁹

Several clinical and laboratory variables have been associated with worse outcomes, including younger age; cerebral edema; neurological status; multisystem organ failure; prolonged PT; elevated levels of ammonia (NH₃), bilirubin, and creatinine; hepatic encephalopathy (HE) grade at onset and peak; and pediatric end-stage liver disease (PELD) score.^{7,9-15} Despite advances in critical care and LT, PALF outcomes remain suboptimal.^{13,16-19} For eligible patients, LT can be lifesaving, with reported survival rates of 62-83% when modern supportive care is combined with transplantation.^{1,6,20}

This study retrospectively analyzed, over a six-year period, children diagnosed with ALF in our pediatric intensive care unit (PICU). We aimed to describe etiologies, clinical course,

and outcomes and to explore associations between commonly used prognostic markers, such as PELD and pediatric risk of mortality (PRISM) scores, and survival outcomes.

Materials and Methods

We retrospectively reviewed the medical records of 53 patients with PALF who were admitted to our PICU between January 2014 and December 2019 (a six-year period). Patients from the neonatal period up to 18 years of age were eligible. Children diagnosed with ALF who required PICU care were included. The study was approved by the Ankara University Institutional Review Board (approval no: İ5-215-19, date: 14.11.2019). As this was a retrospective chart review, informed consent was waived by the institutional review board. The data were collected through medical record review; therefore, individual patient consent was not required.

Demographic data, including age and sex, were collected, along with PALF etiology, HE grades, and PRISM scores at admission. For patients under 12 years of age, PELD was calculated; for patients aged 12 years or older, the model for end-stage liver disease (MELD) score was calculated using the online calculator.²¹ Patient information, including presenting complaints, symptom duration, parental consanguinity, growth failure, and prior drug exposures, was recorded. Physical examination findings at admission, including ascites, jaundice, hepatomegaly, splenomegaly, edema, and encephalopathy, were also documented.

Etiologies were classified into six categories: metabolic, autoimmune, infectious, drug- or toxin-related, indeterminate, and other or unclassified. The term "indeterminate" was defined as cases in which no viral markers, drug or toxin exposure, or metabolic causes were identified. "Other" included rare or unclassified causes that did not fit into the main categories.

To explore potential prognostic differences by etiology, patients were divided into two groups: group 1 comprised patients with toxic ALF, and group 2 comprised patients with ALF from other causes. This classification was based on the

hypothesis that the underlying etiology may influence the severity of organ dysfunction, the response to supportive therapy, and the clinical course. Clinical and laboratory parameters, including PELD or MELD scores, alanine aminotransferase (ALT), aspartate aminotransferase, NH_3 , PT, INR, and the need for invasive or non-invasive respiratory support, plasma exchange (PEX), and continuous renal replacement therapy (CRRT), were compared between groups to evaluate etiology-specific differences in disease progression and outcomes.

Supportive therapies were administered according to each patient's clinical status and etiology, including electrolyte and glucose replacement, N-acetylcysteine, antibiotics, laxatives, H₂-receptor blockers, PEX, CRRT, respiratory support, and LT. Indications for LT included progressive coagulopathy or worsening HE despite maximal supportive care. Radiological assessments (abdominal ultrasound, hepatobiliary Doppler, abdominal computed tomography), electroencephalography, and liver biopsy were performed when clinically indicated. Complications, including sepsis, gastrointestinal bleeding, cerebral edema, seizures, spontaneous bacterial peritonitis, acute kidney injury, and adrenal failure, were recorded. Neurological outcomes at discharge were assessed using the pediatric cerebral performance category scale (PCPC).²²

Definitions

PALF was defined according to the criteria established by the PALF study group.²³ The severity of HE was graded clinically as follows: grade 1, slowness of mentation; grade 2, drowsiness and confusion; grade 3, very sleepy but arousable, combative, and hyperreflexic; and grade 4, unconsciousness with decerebrate or decorticate posturing.²⁴ PRISM scores were calculated using 14 physiological variables,²⁵ while PELD and MELD scores were determined as previously described for patients aged 12 years or older and for those younger than 12 years, respectively.^{26,27} Pediatric malnutrition was defined using weight-for-height z-score (WHz) or body mass index for age, with WHz considered a sensitive early indicator of growth faltering.²⁸

Statistical Analysis

All statistical analyses were conducted using IBM SPSS Statistics for Windows, version 11.0 (IBM Corp., Armonk, NY, USA). Continuous variables were first evaluated for normality using the Shapiro-Wilk test. Variables with approximately normal distributions were presented as mean \pm standard deviation, whereas non-normally distributed variables were reported as median (interquartile range). Median values were primarily used for variables with skewed distributions, such as PICU length of stay, ALT, blood ammonium level, INR, PELD and MELD scores.

Comparisons between groups were performed using Student's t-test for normally distributed continuous variables and the Mann-Whitney U test for non-normally distributed continuous variables. Categorical variables were analyzed using the chi-square test or Fisher's exact test, as appropriate.

To identify potential prognostic factors associated with poor outcomes (death or LT), logistic regression analysis was performed, including key clinical and laboratory parameters such as ALT, INR, PELD, and NH_3 levels.

A p-value <0.05 was considered statistically significant; and significant values are highlighted in bold. This approach ensures that the selection of descriptive statistics and inferential tests is consistent with the data distribution and aligned with the study's objective of identifying prognostic indicators in PALF.

Results

Over a 6-year period, 53 children diagnosed with PALF were evaluated; 29 (54.7%) were male. At presentation, the median age was 42 months, and parental consanguinity was present in 18 patients (34%). The etiology was identified in 36 patients, while in 17 (32.1%) it remained indeterminate. Toxic hepatitis was the most frequent cause, accounting for 23 cases (43.4%), followed by metabolic disorders (7 cases, 13.2%), infectious diseases (1 case, 1.9%), and other or unclassified causes (5 cases, 9.4%) (Table 1). Age distribution, presenting complaints, and clinical findings are summarized in Table 1.

Neurological assessment at admission revealed normal function in 19 patients (35.8%), HE grade I-II in 16 (30.2%), grade III in 14 (26.4%), and grade IV in 4 (7.5%). Laboratory results and treatment details are summarized in Table 1.

Respiratory support was not required in 28 patients (52.8%), whereas 20 patients (37.7%) required invasive mechanical ventilation, 4 patients (7.5%) required non-invasive ventilation, and 1 patient (1.8%) required high-flow nasal cannula oxygen. PEX was performed in 22 patients (41.5%), predominantly among patients in the indeterminate-etiology group. CRRT was required in 11 patients (20.8%), including continuous venovenous hemodialysis (n=5), continuous venovenous hemodiafiltration (n=5), and peritoneal dialysis (n=1). The majority of patients requiring CRRT had metabolic ALF. LT was performed in 7 patients (13.2%), all from living donors, with the most frequent indications being indeterminate and toxic- or drug-related ALF.

During the PICU stay, complications included suspected or proven sepsis in 20 patients (37.7%), gastrointestinal bleeding in 5 patients (9.4%), cerebral edema in 5 patients (9.4%), acute kidney injury in 10 patients (18.9%), and adrenal failure

Table 1. Demographic, clinical, laboratory characteristics, and treatments of children with pediatric acute liver failure

| Variable | n/median (IQR) | % (fraction) | Unit/notes |
|---------------------------|--------------------------|--------------|---|
| Age group | | | |
| >1 month | 2 | 4% (2/53) | |
| 1-12 months | 14 | 26% (14/53) | |
| 1-5 years | 17 | 32% (17/53) | |
| >5 years | 20 | 38% (20/53) | |
| PALF etiology | | | |
| Toxic | 23 | 43% (23/53) | Mushroom 8, drug overdose 15 |
| Indeterminate | 17 | 32% (17/53) | |
| Metabolic | 7 | 13% (7/53) | Urea cycle 3, MMA 1, tyrosinemia type 1 1, mitochondrial 1, orotic aciduria 1 |
| Other | 5 | 9% (5/53) | |
| Infectious | 1 | 2% (1/53) | |
| Complaints | | | |
| Nausea and vomiting | 33 | 62% (33/53) | |
| Confusion | 28 | 52% (28/53) | |
| Weakness | 17 | 32% (17/53) | |
| Jaundice | 10 | 18% (10/53) | |
| Diarrhea | 5 | 9% (5/53) | |
| Weight loss | 4 | 8% (4/53) | |
| Abdominal pain | 2 | 4% (2/53) | |
| Fever | 1 | 2% (1/53) | |
| Bloody stool | 1 | 2% (1/53) | |
| Cough | 1 | 2% (1/53) | |
| Clinical findings | | | |
| Hepatomegaly | 17 | 33% (17/53) | |
| Jaundice | 16 | 30% (16/53) | |
| Splenomegaly | 8 | 16% (8/53) | |
| Edema | 3 | 5% (3/53) | |
| Ascites | 1 | 2% (1/53) | |
| Rash | 1 | 2% (1/53) | |
| Laboratory results | | | |
| Hemoglobin | 10.8 (9.1-12.3) | | g/dL |
| WBC | 8.928 (5.100-12.400) | | cells/mm ³ |
| Platelet count | 199.000 (85.000-325.000) | | cells/mm ³ |
| PT | 31.2 (14-49) | | Second |
| APTT | 61.4 (36-86) | | Second |
| INR | 2.51 (1.7-3.3) | | - |
| ALT | 168.7 (90-280) | | U/L |
| AST | 1.423 (450-2.600) | | U/L |
| GGT | 123 (55-190) | | U/L |
| Total bilirubin | 5.8 (2.2-9.0) | | mg/dL |
| Direct bilirubin | 2.6 (1.0-4.5) | | mg/dL |
| Total protein | 5.6 (4.9-6.2) | | g/dL |
| Albumin | 3.4 (2.9-3.9) | | g/dL |
| BUN | 12.4 (6-18) | | mg/dL |
| Creatinine | 0.53 (0.3-0.7) | | mg/dL |
| Glucose | 92 (72-110) | | mg/dL |
| Alpha-fetoprotein | 4.746 (1.200-8.100) | | U/L |
| Alpha-1 antitrypsin | 1.5 (1.0-2.0) | | mg/dL |
| Blood ammonium | 24.1 (12-35) | | µmol/L |

Table 1. Continued

| Variable | n/median (IQR) | % (fraction) | Unit/notes |
|---|----------------|--------------|------------|
| Required treatments | | | |
| Fluid, electrolyte, and glucose replacement | 53 | 100% (53/53) | |
| N-acetyl cysteine | 51 | 96% (51/53) | |
| H2 blocker | 46 | 87% (46/53) | |
| Oral/IV antibiotics | 38 | 71% (38/53) | |
| Laxative | 37 | 70% (37/53) | |
| Antifungal therapy | 30 | 57% (30/53) | |
| L-ornithine/L-aspartate | 29 | 55% (29/53) | |
| Total parenteral nutrition | 28 | 53% (28/53) | |
| Anticonvulsants | 9 | 17% (9/53) | |
| Hypertonic saline infusion | 8 | 15% (8/53) | |

IQR: Interquartile range, PALF: Pediatric acute liver failure, MMA: Methylmalonic acidemia, WBC: White blood cell, PT: Prothrombin time, APTT: Activated partial thromboplastin time, INR: International normalized ratio, ALT: Alanine aminotransferase, AST: Aspartate aminotransferase, GGT: Gamma-glutamyl transferase, BUN: Blood urea nitrogen, IV: Intravenous

Table 2. Clinical and laboratory differences between toxic/drug-induced and other pediatric acute liver failure groups

| Parameter | Group 1 Median ± SD | Group 2 Median ± SD | p-value (test used) |
|----------------------------|------------------------|------------------------|-------------------------|
| PICU length of stay (days) | 3.9±4.02 | 10.03±10.71 | 0.07 (Mann-Whitney U) |
| ALT (U/L) | 65±32 | 514±259 | 0.021 (Mann-Whitney U) |
| Ammonium (µmol/L) | 107±63.8 | 286.7±467.5 | 0.548 (Mann-Whitney U) |
| INR | 2±1.07 | 2.85±1.32 | 0.003 (Mann-Whitney U) |
| PELD score | 6±4.16 | 27±9.05 | 0.0001 (Mann-Whitney U) |
| MELD score | 14±7.97 | 33±16.8 | 0.456 (Mann-Whitney U) |

CRRT and PEX were initiated based on clinical criteria, including severe encephalopathy, worsening renal function, fluid overload, or laboratory indicators of liver failure. Significance was initially evaluated at p<0.05. After Bonferroni correction for multiple comparisons, the adjusted significance threshold is 0.005; therefore, differences in CRRT and PEX usage should be interpreted cautiously.
SD: Standard deviation, PICU: Pediatric intensive care unit, ALT: Alanine aminotransferase, INR: International normalized ratio, PELD: Pediatric end-stage liver disease, MELD: Model for end-stage liver disease

in 1 patient (1.8%). At discharge, PCPC scores were 1 in 32 patients (60.4%), 2 in 8 patients (15.1%), 3 in 3 patients (5.7%), and 6 in 10 patients (18.9%). The mean PICU length of stay was 7.38±9 days (median 4 days). Overall survival was 81.1% (43 patients); there were 10 deaths (18.9%), which occurred most commonly in patients with metabolic disease

Table 2 summarizes disease severity scores and key laboratory parameters in patients with toxic- or drug-induced ALF (group 1) compared with patients with ALF from other causes (group 2). Group 1 exhibited lower PELD scores, ALT levels, and INR values, indicating milder liver injury. Although MELD and PRISM scores were higher in group 2, these differences did not reach statistical significance. Use of CRRT and PEX was more common in group 2; however, after applying the Bonferroni correction for multiple comparisons (adjusted significance threshold of 0.005), these differences were not statistically significant. Both CRRT and PEX were initiated based on established clinical criteria, including severe encephalopathy, worsening renal function, fluid overload, or abnormal laboratory markers indicative of liver failure.

Notably, five patients initially classified as having indeterminate PALF underwent whole-genome sequencing during long-term follow-up, resulting in definitive diagnoses in all cases. These included mitochondrial depletion syndrome and 3-beta-hydroxy-delta-5-C-27-steroid dehydrogenase deficiency, both established causes of PALF; biotinidase deficiency, a rare metabolic contributor to liver dysfunction; and spinocerebellar ataxia type 21 coexisting with Ehlers-Danlos syndrome type 3, which are unlikely to cause liver failure directly but may reflect broader multisystem involvement.

Discussion

ALF, although rare, can be fatal. While survival rates have improved due to advances in intensive care and timely LT, no specific medical therapy has been established.¹ This study aimed to evaluate the etiological characteristics and prognostic outcomes of children admitted to our PICU between January 2014 and December 2019.

Consanguinity is reported in up to 10% of the global population²⁹ and 25.1% of the population in Türkiye;³⁰

in our cohort it was observed in 34% of patients. A one-sample proportion Z-test comparing our cohort to the national rate yielded a Z-score of 1.49 ($p=0.135$), indicating that this difference was not statistically significant. Therefore, although numerically higher, consanguinity in our cohort cannot be considered significantly more frequent than the national average.

In our series, toxic drug-related (43.3%) and indeterminate (32.1%) etiologies were the most common causes of ALF. International studies have reported an indeterminate-etiology as the predominant finding.^{1,31,32} In developed countries, ALF secondary to viral hepatitis accounts for less than 10% of cases.^{6,33} A prior Turkish study conducted between 1997 and 2003 reported infectious causes in 35% of cases.³⁴ In contrast, none of our patients had hepatitis-related ALF, likely reflecting improved sanitation, rising socioeconomic standards, and the introduction of the hepatitis A vaccination program in Türkiye in October 2012.

Wild mushroom ingestion is a recognized cause of toxic ALF. Globally, more than 5,000 species of mushrooms exist, approximately 3% of which are poisonous.^{35,36} In Türkiye, mushroom poisoning is primarily due to cyclopeptide toxins,^{37,38} and the specific species ingested are unknown in over 90% of cases.^{38,39} In our cohort, most cases of toxic ALF were caused by mushroom poisoning. Particular attention should be paid to children with a family history of poisoning, especially in regions with seasonal agricultural workers engaged in mushroom cultivation. Public education and healthcare-provider awareness are essential, as clinical presentations vary depending on the species ingested and children are at high risk for exposure to wild or improperly cooked mushrooms.³⁷

Although intoxications with colchicine and metformin were classified as toxic ALF, these agents do not primarily target hepatocytes, and management is guided by systemic toxicity rather than by liver-specific failure. These patients were included because their hospital courses were severe and prolonged, requiring PICU admission and management of liver dysfunction as part of multisystem involvement. Colchicine intoxication was particularly relevant to Familial Mediterranean Fever, an autosomal recessive autoinflammatory disease prevalent in the Turkish population (1 in 400-1,000).⁴⁰⁻⁴² Children treated with colchicine may be at increased risk of toxicity, highlighting the need to limit inappropriate or excessive exposure to colchicine.

The most common presenting symptoms and physical findings were nausea, vomiting, confusion, jaundice, and hepatomegaly, consistent with previous studies from Türkiye.^{34,43} Notably, no cases of Wilson's disease were identified. One patient developed ALF secondary to varicella-zoster virus (VZV) infection despite the absence of underlying immunosuppression, which contrasts with prior reports

linking VZV-induced ALF to immunocompromised states.⁴⁴ Liver ultrasound was the most frequently used radiological modality, in line with previous studies.⁴⁵

In our cohort, survival without LT was 67.9%, which is higher than previously reported rates of 28-33%.^{6,7,44} Early referral and timely supportive intensive care likely contributed to improved spontaneous survival.⁴⁶ LT was performed in seven patients, all of whom survived and were discharged from the PICU, thereby highlighting its critical role in improving prognosis.⁴⁷ CRRT, PEX, and LT were performed in 21.8%, 41.5%, and 13.2% of patients, respectively, compared with 18%, 14%, and 50% of patients reported by Di Giorgio et al.⁴⁸

Evaluation of prognostic factors revealed that patients with toxic drug-related ALF required fewer interventions-including IMV, PEX, and CRRT-than did patients with ALF from other etiologies. In our cohort, toxic or drug-related ALF was associated with a relatively more favorable clinical course, consistent with previous reports.¹

Study Limitations

This study has several limitations. Its retrospective design and relatively small, single-center sample limit the generalizability of the findings. A substantial proportion of patients remained without a definitive diagnosis, highlighting gaps in current knowledge of PALF etiology and the limitations of available diagnostic tools. The absence of a standardized severity grading system for PALF complicates comparisons across studies and hinders the development of universally accepted clinical guidelines. Although prognostic indicators, such as PELD and PRISM scores, were assessed, the lack of validated PALF-specific models limits the accuracy of outcome prediction. Future multicenter prospective studies employing standardized criteria and advanced molecular diagnostics are warranted to address these challenges.

Conclusion

PALF is a life-threatening condition that requires prompt recognition and intensive management. Early referral to a PICU and, when indicated, to an LT center markedly improves spontaneous survival. Identifying patients who require LT is critical, as timely transplantation can be life-saving. Children with PALF should be closely monitored, with careful attention to relevant clinical and laboratory parameters. Supportive therapies-including all forms of PEX and CRRT-play a vital role in survival and may serve as a bridge to LT. Promoting organ donation is particularly important in regions with limited cadaveric transplant availability, as LT remains the definitive life-saving intervention.

Ethics

Ethics Committee Approval: The study was approved by the Ankara University Institutional Review Board (approval no: İ5-215-19, date: 14.11.2019).

Informed Consent: As this was a retrospective chart review, informed consent was waived by the institutional review board. The data were collected through medical record review; therefore, individual patient consent was not required.

Footnotes

This manuscript was presented at the 17th Turkish International Pediatric Intensive Care and Emergency Congress, Antalya, Türkiye, October 16, 2021.

Authorship Contributions

Surgical and Medical Practises: F.A., T.K., E.G., E.B., Z.K., C.T.K., M.K., S.F., E.İ., D.B., A.K., Concept: F.A., T.K., Z.K., C.T.K., E.İ., Design: F.A., T.K., Z.K., Data Collection or Processing: F.A., T.K., B.D.E., E.İ., Analysis or Interpretation: F.A., T.K., Z.K., B.D.E., E.İ., Literature Search: F.A., Writing: F.A., T.K., E.İ.

Conflict of Interest: No conflict of interest was declared by the authors.

One of the authors of this article (T.K.) is a member of the Editorial Board of this journal. He was completely blinded to the peer review process of the article.

Financial Disclosure: The authors declared that this study received no financial support.

References

- Squires RH Jr, Shneider BL, Bucuvalas J, Alonso E, Sokol RJ, et al. Acute liver failure in children: the first 348 patients in the pediatric acute liver failure study group. *J Pediatr*. 2006;148:652-8.
- Lutfi R, Abulebda K, Nitu ME, Molleston JP, Bozic MA, et al. Intensive care management of pediatric acute liver failure. *J Pediatr Gastroenterol Nutr*. 2017;64:660-70.
- Shanmugam NP, Bansal S, Greenough A, Verma A, Dhawan A. Neonatal liver failure: aetiologies and management—state of the art. *Eur J Pediatr*. 2011;170:573-81.
- Dhawan A. Acute liver failure in children and adolescents. *Clin Res Hepatol Gastroenterol*. 2012;36:278-83.
- O'Grady JG, Wendon J. Acute liver failure. In: Weinstein WM, Hawkey CJ, Bosch J, (eds). *Clinical gastroenterology and hepatology*. 1st ed. Philadelphia: Elsevier Inc.; 2005:745-53.
- Lee WS, McKiernan P, Kelly DA. Etiology, outcome and prognostic indicators of childhood fulminant hepatic failure in the United Kingdom. *J Pediatr Gastroenterol Nutr*. 2005;40:575-81.
- Ciocca M, Moreira-Silva SF, Alegría S, Galoppo MC, Ruttiman R, et al. Hepatitis A as an etiologic agent of acute liver failure in Latin America. *Pediatr Infect Dis J*. 2007;26:711-5.
- Escorsell A, Mas A, de la Mata M; Spanish group for the study of acute liver failure. Acute liver failure in Spain: analysis of 267 cases. *Liver Transpl*. 2007;13:1389-95.
- Liu E, MacKenzie T, Dobyns EL, Parikh CR, Karrer FM, et al. Characterization of acute liver failure and development of a continuous risk of death staging system in children. *J Hepatol*. 2006;44:134-41.
- Durand P, Debray D, Mandel R, Baujard C, Branchereau S, et al. Acute liver failure in infancy: a 14-year experience of a pediatric liver transplantation center. *J Pediatr*. 2001;139:871-6.
- Alper G, Jarjour IT, Reyes JD, Towbin RB, Hirsch WL, et al. Outcome of children with cerebral edema caused by fulminant hepatic failure. *Pediatr Neurol*. 1998;18:299-304.
- Psacharopoulos HT, Mowat AP, Davies M, Portmann B, Silk DB, et al. Fulminant hepatic failure in childhood: an analysis of 31 cases. *Arch Dis Child*. 1980;55:252-8.
- Rivera-Penera T, Moreno J, Skaff C, McDiarmid S, Vargas J, et al. Delayed encephalopathy in fulminant hepatic failure in the pediatric population and the role of liver transplantation. *J Pediatr Gastroenterol Nutr*. 1997;24:128-34.
- Nicolette L, Billmire D, Faulkenstein K, Pierson A, Vinocur C, et al. Transplantation for acute hepatic failure in children. *J Pediatr Surg*. 1998;33:998-1002.
- Azhar N, Ziraldo C, Barclay D, Rudnick DA, Squires RH, et al. Analysis of serum inflammatory mediators identifies unique dynamic networks associated with death and spontaneous survival in pediatric acute liver failure. *PLoS One*. 2013;8:e78202.
- Corbally MT, Rela M, Heaton ND, Ball C, Portmann B, et al. Orthotopic liver transplantation for acute hepatic failure in children. *Transpl Int*. 1994;7:s104-6.
- Bhaduri BR, Mieli-Vergani G. Fulminant hepatic failure: pediatric aspects. *Semin Liver Dis*. 1996;16:349-55.
- Rakela J, Perkins JD, Gross JB Jr, Hayes DH, Plevak DJ, et al. Acute hepatic failure: the emerging role of orthotopic liver transplantation. *Mayo Clin Proc*. 1989;64:424-8.
- Devictor D, Desplanques L, Debray D, Ozier Y, Dubousset AM, et al. Emergency liver transplantation for fulminant liver failure in infants and children. *Hepatology*. 1992;16:1156-62.
- Ee LC, Shepherd RW, Cleghorn GJ, Lewindon PJ, Fawcett J, et al. Acute liver failure in children: a regional experience. *J Paediatr Child Health*. 2003;39:107-10.
- United Network for Organ Sharing. UNOS | United Network for Organ Sharing [Internet]. Available at: <https://unos.org/> Accessed: December, 2009.
- Pollack MM, Holubkov R, Funai T, Clark A, Moler F, et al. Relationship between the functional status scale and the pediatric overall performance category and pediatric cerebral performance category scales. *JAMA Pediatr*. 2014;168:671-6.
- Ng VL, Li R, Loomes KM, Leonis MA, Rudnick DA, et al. Outcomes of children with and without hepatic encephalopathy from the pediatric acute liver failure study group. *J Pediatr Gastroenterol Nutr*. 2016;63:357-64.
- Riordan SM, Williams R. Treatment of hepatic encephalopathy. *N Engl J Med*. 1997;337:473-9.
- Carroll CL, Goodman DM, Superina RA, Whittington PF, Alonso EM. Timed pediatric risk of mortality scores predict outcomes in pediatric liver transplant recipients. *Pediatr Transplant*. 2003;7:289-95.
- Swenson SM, Roberts JP, Rhee S, Perito ER. Impact of the pediatric end-stage liver disease (PELD) growth failure thresholds on mortality among pediatric liver transplant candidates. *Am J Transplant*. 2019;19:3308-18.
- Peng Y, Qi X, Guo X. Child-pugh versus MELD score for the assessment of prognosis in liver cirrhosis: a systematic review and meta-analysis of observational studies. *Medicine (Baltimore)*. 2016;95:e2877.

28. Bouma S. Diagnosing pediatric malnutrition: paradigm shifts of etiology-related definitions and appraisal of the indicators. *Nutr Clin Pract.* 2017;32:52-67.
29. Oniya O, Neves K, Ahmed B, Konje JC. A review of the reproductive consequences of consanguinity. *Eur J Obstet Gynecol Reprod Biol.* 2019;232:87-96.
30. Tunçbilek E. Clinical outcomes of consanguineous marriages in Turkey. *Turk J Pediatr.* 2001;43:277-9.
31. Kathemann S, Bechmann LP, Sowa JP, Manka P, Dechêne A, et al. Etiology, outcome and prognostic factors of childhood acute liver failure in a German single center. *Ann Hepatol.* 2015;14:722-8.
32. Sundaram SS, Alonso EM, Narkewicz MR, Zhang S, Squires RH, et al. Characterization and outcomes of young infants with acute liver failure. *J Pediatr.* 2011;159:813-8.
33. Poddar U, Thapa BR, Prasad A, Sharma AK, Singh K. Natural history and risk factors in fulminant hepatic failure. *Arch Dis Child.* 2002;87:54-6.
34. Aydoğdu S, Özgenç F, Yurtsever S, Akman SA, Tokat Y, et al. Our experience with fulminant hepatic failure in Turkish children: etiology and outcome. *J Trop Pediatr.* 2003;49:367-70.
35. Mushroom poisoning. *Lancet.* 1980;2:351-2.
36. Gonmori K, Yoshioka N. The examination of mushroom poisonings at Akita University. *Leg Med (Tokyo).* 2003;5:s83-6.
37. Eren SH, Demirel Y, Ugurlu S, Korkmaz I, Aktas C, et al. Mushroom poisoning: retrospective analysis of 294 cases. *Clinics (Sao Paulo).* 2010;65:491-6.
38. Lin YM, Wang TL. Mushroom poisoning. *Ann Disaster Med.* 2004;3:8-11.
39. Litovitz TL, Klein-Schwartz W, Caravati EM, Youniss J, Crouch B, et al. 1998 annual report of the American Association of poison control centers toxic exposure surveillance system. *Am J Emerg Med.* 1999;17:435-87.
40. Onen F. Familial Mediterranean fever. *Rheumatol Int.* 2006;26:489-96.
41. Celiksoy MH, Dogan C, Erturk B, Keskin E, Ada BS. The *MEFV* gene and its association with Familial Mediterranean fever, severe atopy, and recurrent respiratory tract infections. *Allergol Immunopathol (Madr).* 2020;48:430-40.
42. Ben-Chetrit E, Touitou I. Familial Mediterranean fever in the world. *Arthritis Rheum.* 2009;61:1447-53.
43. Barış Z, Saltik Temizel IN, Uslu N, Usta Y, Demir H, et al. Acute liver failure in children: 20-year experience. *Turk J Gastroenterol.* 2012;23:127-34.
44. Brewer EC, Hunter L. Acute liver failure due to disseminated varicella zoster infection. *Case Reports Hepatol.* 2018;2018:1269340.
45. Westra SJ, Zaninovi AC, Hall TR, Busuttill RW, Kangaroo H, et al. Imaging in pediatric liver transplantation. *Radiographics.* 1993;13:1081-99.
46. Sundaram V, Shneider BL, Dhawan A, Ng VL, Im K, et al. King's College Hospital criteria for non-acetaminophen induced acute liver failure in an international cohort of children. *J Pediatr.* 2013;162:319-23.
47. Kirnap M, Akdur A, Özçay F, Soy E, Yildirim S, et al. Liver transplant for fulminant hepatic failure: a single-center experience. *Exp Clin Transplant.* 2015;13:339-43.
48. Di Giorgio A, Sonzogni A, Picciché A, Alessio G, Bonanomi E, et al. Successful management of acute liver failure in Italian children: a 16-year experience at a referral centre for paediatric liver transplantation. *Dig Liver Dis.* 2017;49:1139-45.



Energy Drink Associated Severe Myocardial Injury in a Child: A Case Report

Çocukta Enerji İçeceği ile İlişkili Şiddetli Miyokardiyal Hasar: Olgu Sunumu

Bayram Bayramov¹, Merve Havan¹, Eda Eyduran¹, Ayşen Durak Aslan¹, Mehmet Gökhan Ramoğlu², Tanıl Kendirli¹

¹Ankara University Faculty of Medicine, Department of Pediatric Critical Care, Ankara, Türkiye

²Ankara University Faculty of Medicine, Department of Pediatric Cardiology, Ankara, Türkiye

Abstract

Energy drinks are sugary beverages containing stimulant compounds that are marketed as providing mental and physical stimulation. Consumption of energy drinks has been associated with tachycardia, and in rare cases, myocardial infarction, myocardial injury and sudden cardiac arrest. In this study, we present the case of a 14-year-old male who experienced severe myocardial injury following repeated consumption of energy drinks. This previously healthy patient presented at the hospital complaining of palpitations, chest pain, breathlessness and vomiting following the consumption of four energy drinks. He was admitted to the intensive care unit due to clinical signs of cardiogenic shock and pulmonary oedema. His echocardiogram revealed ventricular dysfunction and his laboratory findings showed elevated cardiac enzymes and electrocardiogram evidence of myocardial injury. After excluding other possible infectious and non-infectious causes, myocardial injury due to energy drink consumption was suspected. The patient was given oxygen, intravenous fluids, epinephrine, milrinone and diuretics. His clinical and laboratory findings improved completely during follow-up and he was discharged in good health. In conclusion, we would like to emphasise that energy drinks, which are increasingly consumed during adolescence, can cause serious, life-threatening myocardial damage in children when consumed repeatedly and in large quantities.

Keywords: Energy drink, myocardial damage, child

Öz

Enerji içecekleri uyarıcı bileşimler içeren ve zihinsel ve fiziksel uyarıcılar olarak pazarlanan şekerli içeceklerdir. Enerji içeceği tüketimi taşikardi, nadir durumlarda miyokard enfarktüsü, miyokard hasarı ve ani kalp durması ile ilişkilendirilmiştir. Burada, art arda enerji içeceği tükettikten sonra ciddi miyokard hasarı gelişen 14 yaşında bir erkek adölesanı sunuyoruz. Daha önce sağlıklı olan hasta, 4 enerji içeceği içtikten sonra çarpıntı, göğüs ağrısı, nefes darlığı ve kusma şikayetleriyle hastaneye başvurdu. Çocuk, kardiyojenik şok ve pulmoner ödem klinik bulguları nedeniyle yoğun bakım ünitesine yatırıldı. Hastanın ekokardiyogramında ventriküler disfonksiyon, laboratuvar bulgularında kardiyak enzimlerde yükselme ve elektrokardiyogramda miyokard hasar bulguları görüldü. Hastada diğer olası enfeksiyöz ve enfeksiyöz olmayan nedenler dışlandıktan sonra, enerji içeceği tüketimine bağlı miyokardiyal hasar düşünüldü. Hastaya oksijen, intravenöz sıvılar, epinefrin, milrinon ve diüretikler uygulandı. Takip sırasında klinik ve laboratuvar bulguları tamamen düzeldi ve sağlıklı olarak taburcu edildi. Sonuç olarak, ergenlikte giderek daha fazla tüketilen enerji içeceklerinin, arka arkaya ve büyük miktarlarda tüketildiğinde çocuklarda ciddi, hayatı tehdit eden miyokardiyal hasara neden olabileceğini vurgulamak isteriz.

Anahtar Kelimeler: Enerji içeceği, miyokardiyal hasar, çocuk

Address for Correspondence/Yazışma Adresi: Prof. MD, Tanıl Kendirli, Ankara University Faculty of Medicine, Department of Pediatric Critical Care, Ankara, Türkiye

E-mail: tanilkendirli@gmail.com **ORCID ID:** orcid.org/0000-0001-9458-2803

Received/Geliş Tarihi: 21.05.2025 **Accepted/Kabul Tarihi:** 18.07.2025 **Epub:** 17.09.2025 **Publication Date/Yayınlanma Tarihi:** 01.04.2026

Cite this article as: Bayramov B, Havan M, Eyduran E, Durak Aslan A, Ramoğlu MG, Kendirli T. Energy drink associated severe myocardial injury in a child: a case report. J Pediatr Emerg Intensive Care Med. 2026;13(1):47-51



Introduction

Energy drinks (ED) (e.g., Monster, Redbull, and Rockstar) are defined as beverages containing stimulants such as caffeine and guarana, as well as varying amounts of carbohydrates, amino acids, protein, sodium, vitamins, and other added minerals.¹ The consumption of ED has increased over the last twenty years, as has the number of emergency calls due to their negative effects.² Popular among adolescents, especially young men, ED cause numerous side effects on the neurological, psychiatric, gastrointestinal, renal, and cardiovascular systems due to their high sugar, caffeine, taurine, and other stimulant content.³ The tendency to consume these drinks with alcohol has also increased. This combination poses a risk to the health of children and adolescents as it accelerates adverse cardiovascular events.⁴ Although ED are marketed as performance enhancers, their safety profile remains a cause for concern.

When consumed repeatedly or alongside other substances, they can cause severe, life-threatening myocardial damage, arrhythmias, infections and autoimmune processes.^{2,5} Here, we present the case of a patient admitted to the paediatric intensive care unit (PICU) with myocardial ischaemia, heart failure, pulmonary oedema, and cardiogenic shock who had consumed several ED at once.

Case Report

A fourteen-year-old male patient was admitted to the pediatric emergency department of another city, complaining of palpitations, compressive chest pain radiating to the left arm, and vomiting. As the patient had clinically severe breathing difficulties and required intensive care, we agreed to admit the patient. The patient was admitted to Ankara University, by ground transport vehicle. On admission to our PICU, physical examination revealed tachycardia, tachypnea, diminished breath sounds in the right lower lobe, and bilateral diffuse rales. The liver was palpable under the ribs. The other examinations were normal. The chest radiograph showed an elevation of the cardiothoracic index and interstitial edema. The patient's medical and family history was unremarkable. However, it was revealed that he consumed ED 1-2 times per week and 4, the day before his admission to the hospital. It was stated that the symptoms started approximately 6 hours after ingestion of the ED.

In the complete blood count taken at application: leukocytes (white blood cell): $17.72 \times 10^9/L$ (4.5-12.5), hemoglobin: 16.7 g/dL (12.5-16.2), neutrophil count: $14.43 \times 10^9/L$ (1.5-8). The biochemical parameters were as follows: aspartate aminotransferase 251 u/L (0-50), alanine aminotransferase 66 u/L (0-50), and lactate dehydrogenase 1344 u/L (120-

300). An increase in acute phase reactants (C-reactive protein: 111.2 mg/L, normal <5 mg/L; fibrinogen: 5.72 g/L, normal=2-3.93 g/L) was noted. Chest computed tomography showed significant pulmonary edema in both lungs, especially in the right lung. Electrocardiogram (ECG): sinus tachycardia, widespread ST-segment elevation, T-wave inversions in leads V2-V6 were observed, and there was no voltage suppression (Figure 1). These ECG findings indicated severe myocardial ischemia in the patient. Echocardiography (ECHO) revealed left ventricular (LV) dysfunction and a left ventricular ejection fraction (LVEF) of 27%. Increase in cardiac markers [creatinine kinase-muscle/brain (mass)]: 116.80 ng/mL (n=0-4.87 ng/mL), troponin T: 4016 pg/mL (n=0-14 pg/mL), N-terminal pro B-type natriuretic peptide: 8795 pg/mL (n=0-125 pg/mL) was noted.

To rule out possible causes of myocarditis, viral (parvovirus B19, human herpesvirus-6, Epstein-Barr virus, cytomegalovirus, hepatitis A/B/C, human immunodeficiency virus, varicella, herpes simplex virus 1/2, rubella) and bacterial (*Mycoplasma*, *Bordetella*, *Chlamydia*, *Legionella*, *Streptococcus*) tests are performed, and serological tests (*Brucella*) were negative. The tests for respiratory viruses (influenza A/B, parainfluenza 1/2/3/4, coronavirus OC43/NL63/229E/HKU1, respiratory syncytial virus A/B, rhinovirus, bocavirus, metapneumovirus A/B, adenovirus, enterovirus, parechovirus) were also negative. The metabolic screening (very long-chain fatty acids, carnitine/acylcarnitine analysis) was normal. Blood ethanol and a urine.

The toxicology panel (marijuana, cocaine, and opiates) was not performed because the history and physical examination revealed no evidence. When the patient's history, clinical findings, and laboratory results were evaluated, the patient was diagnosed with ED-induced severe myocardial injury.

The patient was started on intravenous fluids of 1000 cc/m², and inotropic treatment (epinephrine 0.1 mcg/kg/min and milrinone 0.5 mcg/kg/min). To treat pulmonary edema while reducing cardiac workload, a furosemide infusion was administered at a rate of 0.1 mg/kg/hour. Intravenous fluid intake was restricted to 750 cc/m². Since bacterial infection

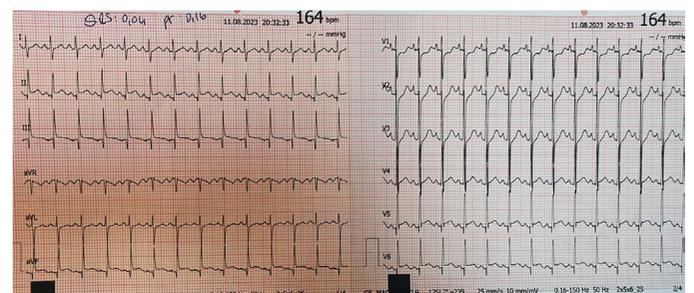


Figure 1. In the first electrocardiogram: sinus tachycardia, widespread ST-segment elevation, T-wave inversions in leads V2-V6 can be seen

could not be ruled out with the patient's current clinical findings, intravenous treatment with ceftriaxone 75 mg/kg/day was started. During follow-up, it was observed that the tachycardia decreased and the systolic functions of the heart improved. Serial echocardiograms were conducted. On the second day of follow-up in the intensive care unit, the ECG showed a significant decrease in ST elevation and T wave inversion in V2-V6 leads.

During the seven-day follow-up in the PICU, a gradual clinical improvement was observed. An improvement in cardiac markers was also observed (Figure 2). The patient's LVEF increased to 62% on follow-up ECHO, and he was transferred to pediatric cardiology on the seventh day.

On the ward, on the 11th day of his hospitalization, the follow-up ECHO showed an ejection fraction of 62% (Figure 3). Milrinone treatment was discontinued. Antibiotic treatment was discontinued due to lack of growth in the blood culture. On the 12th day, he was discharged with the plan to continue the metoprolol and enalapril treatment that was started for heart failure, and was continued as an outpatient. The medical history and physical examination at the outpatient follow-up after discharge revealed no pathologic findings. There were no abnormalities in the cardiac markers, blood count or biochemical parameters. The ECG was in normal

sinus rhythm. At ECHO: LVEF is 62%, with normal systolic function and minimal mitral regurgitation. Informed consent for participating in the study was obtained from the patient's parents.

Discussion

In recent years, the cardiac effects of caffeine have been extensively studied and reported, including tachyarrhythmias, increased blood pressure, decreased vasodilation, and new onset atrial fibrillation.⁶ The stimulant content of ED can lead to increased sympathetic activity, vasoconstriction, and cardiac arrhythmia. It is reported in the literature that caffeinated ED, which are considered a significant source of caffeine, contain about 32 mg of caffeine in 100 mL, doses can contain up to about 152-160 mg of caffeine.

A 250 mL pack of Redbull® ED available in Türkiye contains 80 mg of caffeine, which is more than the amount of caffeine in the same amount of black tea (57 mg). Both acute consumption (>480 mg per day) and chronic consumption (>200 mg per day for more than one week) of caffeine in our patient were associated with adverse cardiovascular events. In addition, the excess of catecholamines stimulated by caffeine, leads to an increase in heart rate and blood pressure as a result of the positive inotropism produced by increased systemic vascular resistance and increased intracellular cyclic adenosine monophosphate. It is known that the taurine contained in these ED has a positive inotropic effect and an arterial antihypertensive effect by attenuating angiotensin II. Hypotension developed in our patient owing to severe myocardial injury-related left ventricular dysfunction. That was a cardiogenic shock state. We improved this clinical condition with inotropics and diuretic drugs.

Another ingredient, guarana, contains xanthine alkaloids such as theobromine, theophylline, and more caffeine than coffee beans.⁷⁻¹⁰ In our case, the presence of symptoms of myocardial ischemia and ventricular dysfunction suggested cardiovascular involvement. In addition, interstitial pulmonary edema developed due to cardiac dysfunction.

The World Health Organization (WHO) points out that ED pose serious health risks, especially for children and adolescents. The high levels of caffeine and other stimulants contained in ED can pose serious health risks to children and adolescents.¹⁰ The negative effects of ED on children include serious health problems such as headaches, sleep disorders, poor school performance, and even problems with heart failure. For these reasons, the sale of ED to children is banned or restricted in some countries. A UK study found that almost half of children from low-income families and a third of children in the UK consume ED at least once a week, demonstrating a

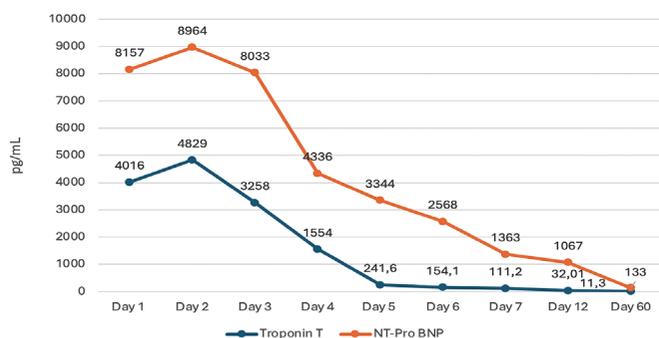


Figure 2. Troponin T and NT-Pro BNP values by day
NT-Pro BNP: N-terminal pro B-type natriuretic peptide

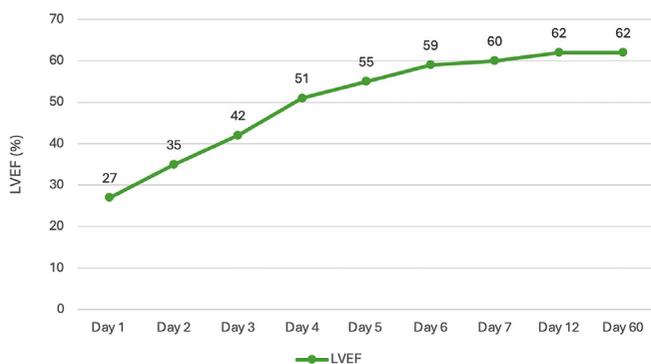


Figure 3. Level of LVEF by day
LVEF: Left ventricular ejection fraction

link between poverty and ED consumption.¹¹ It has also been observed that, children who are better informed about the contents of ED consume them less. For this reason, the WHO recommends raising awareness of the harmful effects of ED and limiting or preventing the consumption of these drinks by children.

The Centers for Disease Control and Prevention report on the adverse effects of ED on children and adolescents is consistent with the recommendations of the WHO.¹⁰

Our patient had the cardiovascular effects mentioned above, but no neuropsychiatric disorder was observed. Moderate to severe adverse effects such as palpitations, shortness of breath, uncontrolled muscle twitching, severe nausea, anxiety, irritability, and electrocardiogram changes have been observed in some young adults when more than one liter of ED is consumed, exceeding the safe amount of caffeine.¹

Many studies have shown that ED are associated with causing a greater increase in high blood pressure compared to placebos. In a recent study, runners were asked to complete an exercise test. The subjects drank one of three ED or a placebo one hour before the test. The results showed that blood pressure was higher in the group that drank than in the placebo group.¹⁰ Among the cardiac side effects of ED, cardiac arrhythmias (35%), coronary vasospasm, aortic aneurysm and dissection, cardiac arrest, QT prolongation, acute cardiomyopathies, hypertension, reversible postural tachycardia syndrome, acute coronary thrombosis and ST elevation myocardial infarction were reported. Caffeine and taurine are associated with compounds that have been shown to increase platelet aggregation, impair endothelial function, and possibly cause hypertension-induced vasospasm.¹¹

In the study, 27 children and adolescents with an average age of 14.49 years consumed ED and a placebo on two consecutive days in accordance with the maximum amount of caffeine recommended by the European Food Safety Authority. The consumption of ED caused a significant increase in the number of supraventricular extrasystoles compared to placebo. Supraventricular tachycardia or malignant ventricular arrhythmias were not observed. It was found that the average heart rate was significantly higher after taking ED. In contrast, corrected QT (QTc) intervals were not affected by ED.⁵

Another prospective study was conducted in our country by Elitok et al.¹² Serious cardiovascular side effects and cardiac arrhythmias have been reported in the literature following the consumption of ED. In this study, the acute effects of the ED Redbull® on ventricular repolarization were investigated using the time between the peak and the end of the electrocardiographic T wave (Tp-e) and the Tp-e/QT ratio. After an eight-hour fast, 50 healthy young participants consumed

355 mL of the ED Redbull®. The Tp-e interval, the Tp-e/QTc ratio and some other electrocardiographic parameters were measured before and two hours after the consumption of Redbull®. Although consumption of the ED Redbull® increases heart rate and diastolic and systolic blood pressure, it does not cause changes in ventricular repolarization when looking at the Tp-e interval and the Tp-e/QTc ratio.

Conclusion

In conclusion, ED can be categorized as dietary supplements, which are not as strictly regulated as foods. For example, the US Food and Drug Administration regulates the caffeine content of sodas, but not the caffeine content of ED. It is recommended that children eat properly and get enough sleep to boost their energy. Pediatricians, parents and educators should be aware of the potential risks associated with ED consumption in children. Caution and education are important to prevent adverse effects.

Further research is needed to establish the factors that make people susceptible, the safe level of ED consumption, and the underlying mechanisms of toxicity.

Ethics

Informed Consent: Informed consent for participating in the study was obtained from the patient's parents.

Footnotes

Authorship Contributions

Surgical and Medical Practices: B.B., M.H., T.K., Concept: B.B., T.K., Design: B.B., E.E., A.D.A., T.K., Data Collection or Processing: B.B., E.E., M.G.R., Analysis or Interpretation: M.H., T.K., Literature Search: B.B., E.E., A.D.A., Writing: B.B., T.K.

Conflict of Interest: One of the authors of this article (T.K.) is a member of the Editorial Board of this journal. He was completely blinded to the peer review process of the article. No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

References

1. Children and adolescents: excessive consumption of energy drinks increases health risk for cardiovascular system. Bundesinstitut für Risikobewertung. Last accessed date: 27.05.2019. Available from: <https://www.bfr.bund.de/cm/349/children-and-adolescents-excessive-consumption-of-energy-drinkshealth-risk-for-cardiovascular-system.pdf>.
2. Ali F, Rehman H, Babayan Z, Stapleton D, Joshi DD. Energy drinks and their adverse health effects: a systematic review of the current evidence. *Postgrad Med.* 2015;127:308-22.

3. Scientific opinion on the safety of caffeine. *EFSA Journal*. 2015;13:4102.
4. Peveler WW, Sanders GJ, Marczynski CA, Holmer B. Effects of energy drinks on economy and cardiovascular measures. *J Strength Cond Res*. 2017;31:882-7.
5. Mandilaras G, Li P, Dalla-Pozza R, Haas NA, Oberhoffer FS. Energy drinks and their acute effects on heart rhythm and electrocardiographic time intervals in healthy children and teenagers: a randomized trial. *Cells*. 2022;11:498.
6. Papamichael CM, Aznaouridis KA, Karatzis EN, Karatzi KN, Stamatelopoulos KS, et al. Effect of coffee on endothelial function in healthy subjects: the role of caffeine. *Clin Sci (Lond)*. 2005;109:55-60.
7. Smith N, Atroch AL. Guarana's journey from regional tonic to aphrodisiac and global energy drink. *Evid Based Complement Alternat Med*. 2010;7:279-82.
8. Patrick M, Kim HA, Oketch-Rabah H, Marles RJ, Roe AL, et al. Safety of Guarana seed as a dietary ingredient: a review. *J Agric Food Chem*. 2019;67:11281-7.
9. Committee on Nutrition and the Council on Sports Medicine and Fitness. Sports drinks and energy drinks for children and adolescents: are they appropriate? *Pediatrics*. 2011;127:1182-9.
10. The buzz on energy drinks. CDC. Last accessed date: 03.09.2025. Available from: <https://www.cdc.gov/healthyschools/nutrition/energy.htm>
11. Breda JJ, Whiting SH, Encarnação R, Norberg S, Jones R, et al. Energy drink consumption in Europe: a review of the risks, adverse health effects, and policy options to respond. *Front Public Health*. 2014;2:134.
12. Elitok A, Öz F, Panc C, Sarıkaya R, Sezikli S, et al. Acute effects of Red Bull energy drink on ventricular repolarization in healthy young volunteers: a prospective study. *Anatol J Cardiol*. 2015;15:919-22.



Hernia Inguinalis Ovarii: A Case of Groin Mass Needing Urgent Attention

Hernia Inguinalis Ovarii: Acil Müdahale Gerektiren Kasık Kitlesi Olgusu

Rashika Mony¹, Prema Choudhary²

¹Pt. Deendayal Upadhyay Memorial Health Sciences and Ayush University, Government Medical College, Mahasamund, Department of Radiodiagnosis, Chhattisgarh, India

²Pt. Deendayal Upadhyay Memorial Health Sciences and Ayush University, Pt. Jawahar Lal Nehru Memorial Medical College, Department of Radiodiagnosis, Chhattisgarh, India

Abstract

Congenital inguinal abnormalities in females vary from benign to potentially life-threatening etiologies. Canal of Nuck hernia is one such condition. Cases with ovarian prolapse, though initially asymptomatic, pose a significant risk of torsion, potentially impacting future fertility and therefore warrant timely surgical management. Herein, we report a case of bilateral canal of Nuck hernia with ovarian herniation in a female infant with a history of prematurity. An appropriate presumptive diagnosis, in conjunction with confirmatory ultrasound, is mandatory to help general pediatricians, pediatric surgeons, and emergency physicians manage cases promptly, as early intervention can significantly reduce the anticipated morbidity.

Keywords: Canal of Nuck hernia, ovarian herniation, prematurity, bilateral, ultrasound

Öz

Kadınlarda doğuştan inguinal anomaliler, iyi huylu olanlardan potansiyel olarak yaşamı tehdit eden etiyolojilere kadar çeşitlilik gösterir. Nuck kanalı hernisi de bu tür bir durumdur. Over prolapsus olan olgular, başlangıçta asemptomatik olsalar da torsiyon riski taşırlar ve bu durum da ileride fertilitiyi etkileyebilir, bu nedenle zamanında cerrahi tedavi gerektirir. Bu çalışmada, prematüre doğum öyküsü olan bir kız bebekte over herniasyonu ile birlikte bilateral Nuck kanalı hernisi olgusu sunulmaktadır. Erken müdahale, beklenen morbiditeyi önemli ölçüde azaltabileceğinden genel pediyatristlerin, pediyatrik cerrahların ve acil tıp hekimlerinin olguları hızlı bir şekilde yönetmelerine yardımcı olmak için, doğrulayıcı ultrason ile birlikte uygun bir ön tanı konulması zorunludur.

Anahtar Kelimeler: Nuck kanalı hernisi, over hernisi, prematüre, bilateral, ultrason

Introduction

The canal of Nuck hernia, a female counterpart of congenital inguinal hernia in males, is due to the patent processus vaginalis, also known as Nuck diverticulum. The canal of Nuck was named after the Dutch anatomist Anton Nuck in 1691. The incidence of female inguinal hernias is 1.9%, and the content in 15-20% of female inguinal hernias is ovaries and/or fallopian tubes.¹ The complications most commonly associated with this condition are incarceration (trapping of hernial

content causing irreducibility), strangulation (compromised blood supply of the trapped organ), and torsion (twisting of abnormally lengthened pedicle causing inviability of the herniated organ), which typically warrant emergency surgery. This includes ovarian herniation where such adverse effects lead to infertility or subfertility, jeopardizing the individual's reproductive potential. Thus, it is imperative to diagnose this condition immediately to avoid needless complexity and inappropriate interventions. In this report, we aim to discuss a case of bilateral canal of Nuck hernia with ovarian content.

Address for Correspondence/Yazışma Adresi: Asst. Prof., Rashika Mony, Pt. Deendayal Upadhyay Memorial Health Sciences and Ayush University, Government Medical College, Mahasamund, Department of Radiodiagnosis, Chhattisgarh, India

E-mail: rashikamony@gmail.com **ORCID ID:** orcid.org/0000-0002-3077-2648

Received/Geliş Tarihi: 14.04.2025 **Accepted/Kabul Tarihi:** 04.08.2025 **Epub:** 18.08.2025 **Publication Date/Yayınlanma Tarihi:** 01.04.2026

Cite this article as: Mony R, Choudhary P. Hernia inguinalis ovarii: a case of groin mass needing urgent attention. J Pediatr Emerg Intensive Care Med. 2026;13(1):52-5



Case Report

A 2-month-old female baby presented with a left-sided inguinal swelling, gradually increasing in size, not associated with an irritable cry or erythema (Figure 1). On examination, a hard, non-tender, reducible swelling was noted in the left side of the groin. A history of prematurity was observed. The closest differential diagnosis considered is abscess, lymphadenopathy, hydrocele, and hernia, and their respective clinical and radiological features are described in Table 1. Ultimately, ultrasound was advised for diagnostic confirmation. On sonography, an ovoid-shaped multi-cystic structure representing the ovary, with a hypoechoic pedicle, is noted in the left inguinal region. On the right side, the hernial sac contained minimal collection, and on crying, herniation of the ovary was noted. Color Doppler study reveals appropriate blood flow in bilateral ovaries. Magnetic resonance imaging (MRI) confirmed the structure as the left inguinal ovary and showed a sac with minimal fluid in the right inguinal region. The right ovary was located near the deep ring. Hence, a diagnosis of bilateral canal of Nuck hernia was made (Figure 2). The patient underwent open bilateral inguinal herniotomy, first on the left followed by the right. Under general anesthesia and aseptic precautions, a transverse inguinal crease incision was made, followed by opening the oblique muscles layer by

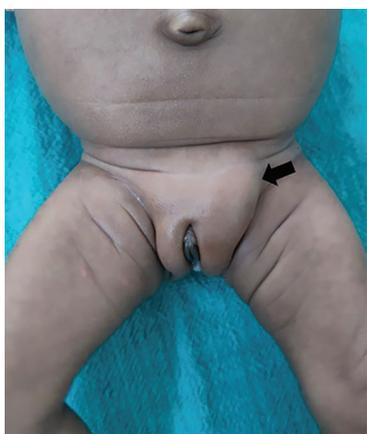


Figure 1. Canal of Nuck hernia presenting as groin mass on the left side (black arrow)

layer. Identification of the sac followed by tracing up to the deep inguinal ring was performed. The sac was opened, a viable ovary was seen, and no obvious adhesions were noted. The contents of the canal are repositioned into the peritoneal cavity, followed by trans-fixation of the sac at the deep ring. Lastly, the sac excision was done and ended with anatomical closure. The follow-up was uneventful. Intraoperative findings validated the imaging-based diagnosis.

Discussion

Embryologically, the invagination of the processus vaginalis, a part of the parietal peritoneum in the inguinal canal, is a normal phenomenon that occurs at 6 months of intrauterine life, helping the process of testicular descent in males. In females, it is a vestigial remnant passing alongside the round ligament and is termed the canal of Nuck. Ideally: at 8 months of intrauterine life, craniocaudal obliteration of this process is observed (Figure 3). In some rare instances, it could remain open in the extrauterine period up to the first year of life.² Incomplete obliteration of this remnant processus can cause hernia or hydrocele. The incidence of herniation is approximately six times higher in males. Right-sided hernia is more common than left-sided hernia because of delayed closure of the right deep ring or the sigmoid colon hindering the left deep ring.³ The contents of this sac may be peritoneal fluid, omental fat, bowel loops, ovary, fallopian tube, and rarely uterus and urinary bladder.⁴

In this case report, we present a female infant with bilateral canal of Nuck containing her ovaries. Normally, the ovaries are prevented from descending into the labia majora by fixation of the proximal gubernaculum between the ovaries and the uterine cornu. Persistent canal of Nuck, coupled with failed closure of the internal ring, or failure of attachment of the proximal gubernaculum to the uterine cornu, provides the defect necessary for the development of an ectopic inguinal ovary. The possible postulated theories include ovaries being pulled into the inguinal canal by their attachments, a shorter round ligament, increased ovarian mobility due to lengthened fallopian tubes, increased intra-abdominal pressure, and a

| Table 1. Clinical and radiological findings of differential diagnosis | | |
|---|---|---|
| Differential diagnosis | Clinical findings | Radiological findings |
| Abscess | Soft swelling; tenderness, local rise in temperature ± erythema | Poorly defined/loculated hypoechoic or anechoic collection with internal debris. |
| Lymphadenopathy | Hard swelling ± tenderness | Well defined mass lesion with variable shape and size. Hyperechoic hilum in benign aetiology and loss of hyperechoic hilum with central hypo echogenicity or necrotic content in malignant aetiology. |
| Hydrocele of canal of Nuck | Soft swelling with no reducibility. | Well defined thin-walled anechoic cystic structure with or without internal septations or debris. |
| Inguinal hernia | Soft swelling ± reducibility; Increase in size with Valsalva manoeuvre. | Herniation of hyperechoic fat or bowel into the canal can be seen. |

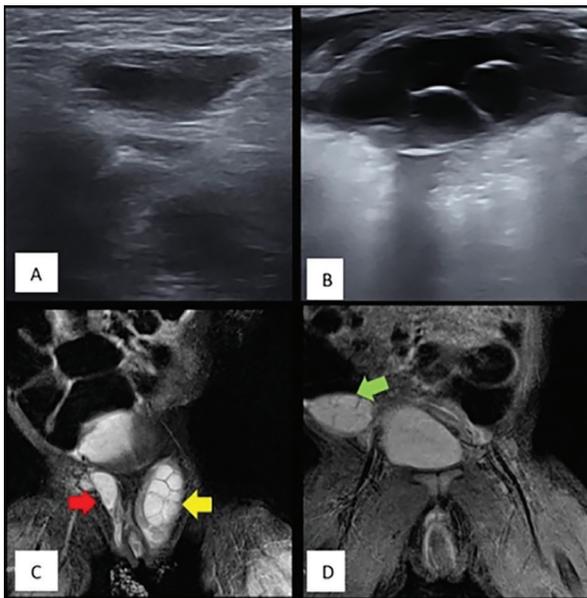


Figure 2. Ultrasonography showing, A) sac containing fluid in right inguinal region, B) ovary in the left side. MRI in coronal section of STIR sequence, C) showing left ovary in left inguinal region (yellow arrow) and sac containing fluid in right inguinal region (red arrow), D) right ovary in right iliac fossa at the level of deep ring (green arrow)
MRI: Magnetic resonance imaging, STIR: Short tau inversion recovery

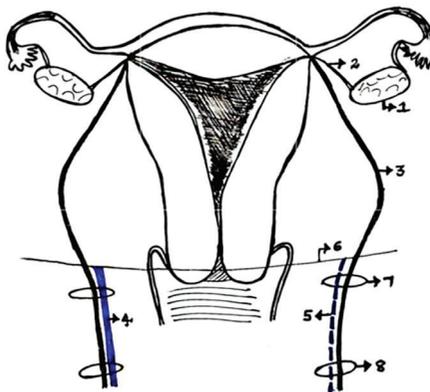


Figure 3. Schematic diagram describing the course of canal of Nuck;
1. Ovary, 2. Ovarian ligament, 3. Round ligament, 4. Patent canal of Nuck, 5. Obliterated canal of Nuck, 6. Partial peritoneum, 7. Deep inguinal ring, 8. Superficial inguinal ring

history of prematurity, which may delay the closure of the processus vaginalis.^{5,6}

Inguinal gonads usually manifest as a groin mass, sometimes, extending up to the labia, with variable reducibility and possibility of pain. Devitalized hernial contents may present on local examination with signs of inflammation, such as localized edema, erythema, and rarely bluish discoloration. Infants may present with irritable cries, whereas adults and children may present with vomiting and abdominal pain.⁷ Though hernia is primarily diagnosed clinically, the definitive diagnosis

is confirmed through imaging modalities, with potential diagnoses being noted in the targeted anatomical region. The differentials so far observed in this region are hernia, hydrocele, lymphadenopathy, abscess, cyst, benign or malignant neoplasms, and rarely vascular and lymphatic malformations, ganglion cyst from the hip, and developmental aberration such as asymmetrical labium majus enlargement.⁸ Various structures have been noted herniating within the canal of Nuck until now, out of which the herniation of reproductive organs becomes urgent.

Ultrasound serves as the first line imaging tool for diagnostic confirmation. Grey-scale imaging combined with Doppler study plays an essential role as real-time scanning with provocative maneuver, helps in better understanding of the herniated organ and its nature. On grey-scale ultrasonography, ovaries appear as an elliptical mass hypoechoic to surrounding tissue with multiple small anechoic cysts similar to the appearance of a chocolate chip cookie, and Doppler study reveals normal stromal vascularity. Ovarian volume enlargement with heterogeneous echogenicity of stroma, peripherally displaced follicles, focal or totally blurred margins with or without adjacent fat stranding, and disappearance of ovarian blood flow are the findings associated with ovarian torsion.^{6,7} In cases of inconclusive sonography, MRI is more advisable than computed tomography (CT), owing to its superior soft tissue contrast and lack of radiation hazard in young infants. The CT pelvis reveals a missing intrapelvic ovary with the pedicle extending into the Nuck diverticulum, and a low-density mass representing the ovary. MRI reveals an intermediate signal mass containing high T2 cysts resembling follicles in the canal of Nuck; sometimes T2 high signal fluid within the sac can be noted.⁹

Management of canal of Nuck hernia involves hernial repair. However, the precise surgical technique for the treatment of canal of Nuck hernia is not well established, and the timing of surgery depends on the contents of the sac and their viability. Similar to the treatment of male congenital inguinal hernia, herniotomy with sac reduction, and high ligation of sac is preferable in young infants.¹⁰ Previous literature has advocated classical herniorrhaphy, especially in the presence of adhesions, whereas other reports have favored hernioplasty as a viable option.¹¹ In adults, hernia repair can be performed through an open anterior approach such as herniorrhaphy and hernioplasty, or laparoscopic techniques such as transabdominal preperitoneal (TAPP) and totally extraperitoneal (TEP). In TAPP, the peritoneum is incised to separate the main peritoneal cavity from the inguinal portion, and a purse string is used to close the peritoneum. In TEP, the peritoneal opening at the internal ring is closed with sutures introduced through a separate groin incision.¹² Intraoperative identification of non-viable ovaries necessitates

oophorectomy. Additional oophoropexy can be considered in cases with repeated episodes of torsion due to their abnormal attachments.¹³

Conclusion

Utmost care should be taken in female infants presenting with a groin mass regardless of symptoms, since ovarian herniation in the canal of Nuck requires early diagnosis and prompt treatment to mitigate infertility risks. Although various surgical techniques have been described in the literature, high ligation herniotomy remains the preferred approach in infants. The management may also differ based on case specifics. Therefore, this case is presented to enhance the corresponding clinicians' awareness and understanding of this uncommon clinical entity.

Ethics

Informed Consent: The consent was obtained from the patients' parents. They were informed that the patient's image and clinical information would be reported in this journal. Her name and initials will not be published and due efforts will be made to conceal her identity.

Footnotes

Authorship Contributions

Surgical and Medical Practices: R.M., Concept: R.M., P.C., Design: R.M., P.C., Data Collection or Processing: R.M., P.C., Analysis or Interpretation: R.M., P.C., Literature Search: R.M., Writing: R.M.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

References

1. Sharma S, Chavan S, Dhyamote A, Chaudhari N. Hernia uterine inguinale. *Saudi Surg J*. 2016;4:84-6.
2. Thomas AK, Thomas RL, Thomas B. Canal of Nuck abnormalities. *J Ultrasound Med*. 2020;39:385-95.
3. Saguintaah M, Eulliot J, Bertrand M, Prodhomme O, Béchard N, et al. Canal of Nuck abnormalities in pediatric female patients. *Radiographics*. 2022;42:541-58.
4. Ozkan OV, Semerci E, Aslan E, Ozkan S, Dolapcioglu K, et al. A right sliding indirect inguinal hernia containing paraovarian cyst, fallopian tube, and ovary: a case report. *Arch Gynecol Obstet*. 2009;279:897-9.
5. Gu J, Liu C. The clinical value of ultrasound in assessing ovarian strangulation in female infants and toddlers with ovarian hernia. *Front Pediatr*. 2024;12:1366516.
6. Scheier E. Inguinal ovarian hernia on point of care ultrasound: case reports and review of the literature. *Emerg Radiol*. 2022;29:215-7.
7. Rees MA, Squires JE, Tadros S, Squires JH. Canal of Nuck hernia: a multimodality imaging review. *Pediatr Radiol*. 2017;47:893-8.
8. Tilva H, Tayade S, Kanjiya A. Contemporary review of masses in the canal of Nuck. *Cureus*. 2023;15:e36722.
9. Nasser H, King M, Rosenberg HK, Rosen A, Wilck E, et al. Anatomy and pathology of the canal of Nuck. *Clin Imaging*. 2018;51:83-92.
10. Okada T, Sasaki S, Honda S, Miyagi H, Minato M, et al. Irreducible indirect inguinal hernia containing uterus, ovaries, and fallopian tubes. *Hernia*. 2012;16:471-3.
11. Cascini V, Lisi G, Di Renzo D, Pappalepore N, Lelli Chiesa P. Irreducible indirect inguinal hernia containing uterus and bilateral adnexa in a premature female infant: report of an exceptional case and review of the literature. *J Pediatr Surg*. 2013;48:e17-9.
12. Ramachandran V, Edwards CF, Bichianu DC. Inguinal hernia in premature infants. *Neoreviews*. 2020;21:e392-403.
13. AlBuainain R, Tahseen W, AlSayed A. Ovarian torsion in the canal of Nuck of a full-term female infant. *Journal of Pediatric Surgery Case Reports*. 2021;69:101864.



Can Social Media Challenges Determine Life or Death? Two Adolescent Cases from the Pediatric Intensive Care Unit

Sosyal Medya Meydan Okumaları Yaşamı mı Ölümü mü Belirliyor? Yoğun Bakımda İzlenen İki Ergen Olgu

© Kıymet Ezgi Aydın, © Fatih Battal

Çanakkale Onsekiz Mart University Faculty of Medicine, Department of Pediatric Intensive Care, Çanakkale, Türkiye

Abstract

Adolescence is a critical developmental period characterized by rapid social, cognitive, and behavioral changes, during which risk-taking behaviors tend to increase. Social media-driven "challenge" activities can pose serious health threats, particularly when reinforced by peer pressure and group dynamics. This report presents two pediatric cases involving previously healthy adolescents who experienced life-threatening consequences as a result of engaging in such risky behaviors, one of which resulted in death. The first case involved a 12-year-old male who consumed approximately 4-5 liters of water in a short time as part of a peer challenge. He presented with seizures and altered mental status secondary to severe hyponatremia (Na^+ : 116 mmol/L) and was admitted to the pediatric intensive care unit. Following individualized fluid therapy and normalization of electrolytes, the patient recovered fully and was discharged. The second case involved an 11-year-old male who experienced sudden aspiration during a eating contest, leading to cardiac arrest. Despite immediate cardiopulmonary resuscitation, intensive support, and advanced resuscitative efforts, no neurological improvement was observed, and the patient was declared deceased on the third day of admission. Both cases underscore that life-threatening complications can arise in healthy adolescents due to risk-laden behaviors influenced by social media. These cases highlight the need for comprehensive risk assessment in adolescent patients, as well as the importance of implementing multidisciplinary preventive strategies in pediatric healthcare practice.

Keywords: Adolescence, social media, risk-taking, pediatric intensive care units, cognition

Öz

Ergenlik dönemi, bireylerin sosyal, bilişsel ve davranışsal olarak hızla değiştiği, bu süreçte risk alma eğilimlerinin arttığı kritik bir gelişim evresidir. Sosyal medya aracılığıyla yayılan dijital meydan okumalar (challenge) özellikle ergen bireylerde akran baskısı ve grup dinamiklerinin etkisiyle ciddi sağlık risklerine neden olabilmektedir. Bu bildiride, sosyal medya kaynaklı meydan okuma davranışlarının neden olduğu, bilinen bir hastalık öyküsü bulunmayan iki sağlıklı ergen bireyde gelişen, biri mortalite ile sonuçlanan iki ciddi olgu sunulmaktadır. Birinci olguda, arkadaş çevresiyle girdiği su içme iddiası sonrası yaklaşık 4-5 litre su tüketen 12 yaşında erkek hasta, gelişen hiponatremi (Na^+ : 116 mmol/L) nedeniyle konvülsiyon geçirmiş ve bilinç bozukluğu tablosuyla çocuk yoğun bakım ünitesine yatırılmıştır. Elektrolit dengesi sağlandıktan sonra tam klinik iyilik haliyle taburcu edilmiştir. İkinci olguda ise, 11 yaşında erkek hasta bir yeme yarışması sırasında ani aspirasyon sonucu kardiyak arrest gelişmesiyle acil müdahale sonrası yoğun bakım ünitesine alınmış; yoğun tedavi ve ileri yaşam desteğine rağmen nörolojik yanıt alınamayan hasta, üçüncü gününde eksitus kabul edilmiştir. Her iki olguda da altta yatan medikal hastalık bulunmamasına rağmen, sosyal medya kaynaklı riskli davranışlar hayati komplikasyonlara yol açmıştır. Bu olgular, pediatri pratiğinde ergen bireylerde riskli davranış öyküsünün ayrıntılı olarak sorgulanması gerektiğini ve önleyici sağlık hizmetlerinin multidisipliner bir yaklaşımla ele alınmasına önemini ortaya koymaktadır.

Anahtar Kelimeler: Ergenlik, sosyal medya, riskli davranış, çocuk yoğun bakım, bilinç

Address for Correspondence/Yazışma Adresi: Assoc. Prof. Fatih Battal, Çanakkale Onsekiz Mart University Faculty of Medicine, Department of Pediatric Intensive Care, Çanakkale, Türkiye

E-mail: battalfatih@hotmail.com **ORCID ID:** orcid.org/0000-0001-9040-7880

Received/Geliş Tarihi: 13.06.2025 **Accepted/Kabul Tarihi:** 21.08.2025 **Epub:** 03.09.2025 **Publication Date/Yayınlanma Tarihi:** 01.04.2026

Cite this article as: Aydın KE, Battal F. Can social media challenges determine life or death? Two adolescent cases from the pediatric intensive care unit. J Pediatr Emerg Intensive Care Med. 2026;13(1):56-61



©Copyright 2026 The Author(s). Published by Galenos Publishing House on behalf of Society of Pediatric Emergency and Intensive Care Medicine. This is an open access article under the Creative Commons Attribution-Attribution-NonCommercial 4.0 (CC BY-NC 4.0) International License.

Introduction

Adolescence is a critical developmental stage in which physical, cognitive and emotional changes are experienced intensely and risk-taking behaviors increase.¹ In this process, the desire to be accepted in peer groups, the fact that impulse control is not yet fully developed, and the influence of digital media can make adolescents more prone to dangerous and unhealthy behaviors.² Digital trends called “challenge”s, which spread rapidly through social media, become widespread among adolescents in a short time and can lead to serious health problems and even life-threatening situations. In this study, we aimed to draw attention to the potential dangers of such digital interactions by presenting two cases of adolescents who were hospitalized in the pediatric intensive care unit (PICU) as a result of risky behaviors caused by social media.

Case Reports

Case 1: Hyponatremia Due to Excessive Water Intake

A 12-year-old male patient with no previous known systemic or psychiatric disease presented to the emergency department because of confusion and a generalized tonic-clonic seizure that developed after he consumed approximately 4-5 liters of water in a short period of time as part of a bet with his friends. In the history taken from the patient’s parents, it was reported that the patient developed confusion and had a seizure shortly after the incident. He hit his head on a hard surface during the seizure. In the initial evaluation in the emergency department, Glasgow Coma score (GCS) was determined as 10, and the patient was in a stupor. Vital signs included peak heart rate 120/min, blood pressure 110/70 mmHg, body temperature 37 °C, and respiratory rate 15/min. Laboratory tests revealed blood gas values at the time of admission: pH 7.38, pCO₂ 44.6 mmHg, HCO₃⁻ 25.1 mmol/L, standard base excess (SBE) +1.3 mmol/L, and lactate 2 mmol/L. Serum glucose level was 110 mg/dL, serum sodium (Na) 116 mmol/L, chloride (Cl⁻) 80 mmol/L, calcium (Ca) 9.1 mg/dL, magnesium (Mg) 1.6 mg/dL, and phosphorus (P) 4.9 mg/dL, uric acid 3.8 mg/dL and urea 13 mg/dL. Hemogram and acute phase reactants were within normal limits. No pathologic findings appeared in liver and kidney function tests. Serum osmolality was 266 mOsm/kg, spot urine Na was 20 mmol/L, urine creatinine was <4 mg/dL, and urine osmolality was 250 mOsm/kg. The patient was hospitalized in the PICU with a prediagnosis of convulsion due to hyponatremia. Lumbar puncture was performed to differentiate between encephalopathy and meningitis. Cerebrospinal fluid examination revealed no findings suggestive of central nervous system infection. Ceftriaxone and acyclovir treatment were started empirically.

Cranial computed tomography (CT) and magnetic resonance imaging (MRI) were within normal limits (Figures 1-2). Electroencephalography (EEG) showed no epileptiform activity. Serum thyroid function tests, adrenocorticotropic hormone (ACTH), cortisol, and electrolyte analysis were performed. Cortisol level was 38.1 µg/dL and ACTH level was 17.5 pg/mL. As a result of the evaluations, the findings were thought to be compatible with primary polydipsia.

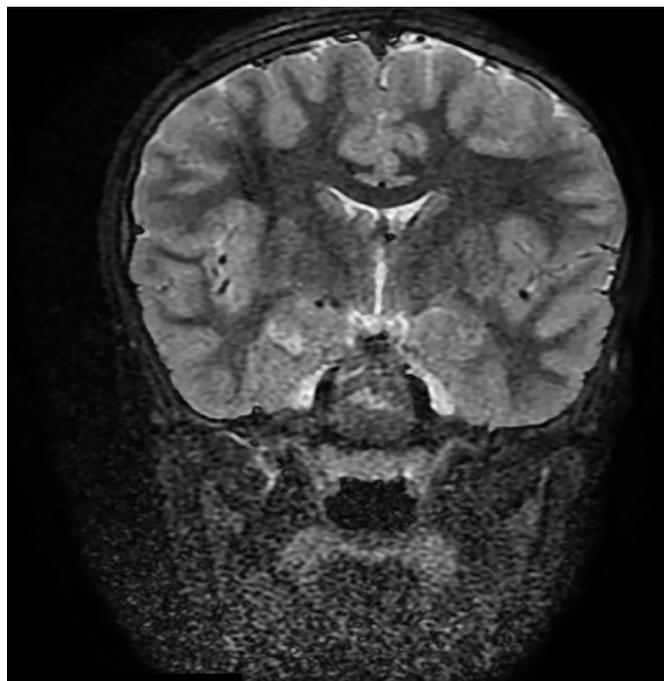


Figure 1. Cranial MRI
MRI: Magnetic resonance imaging

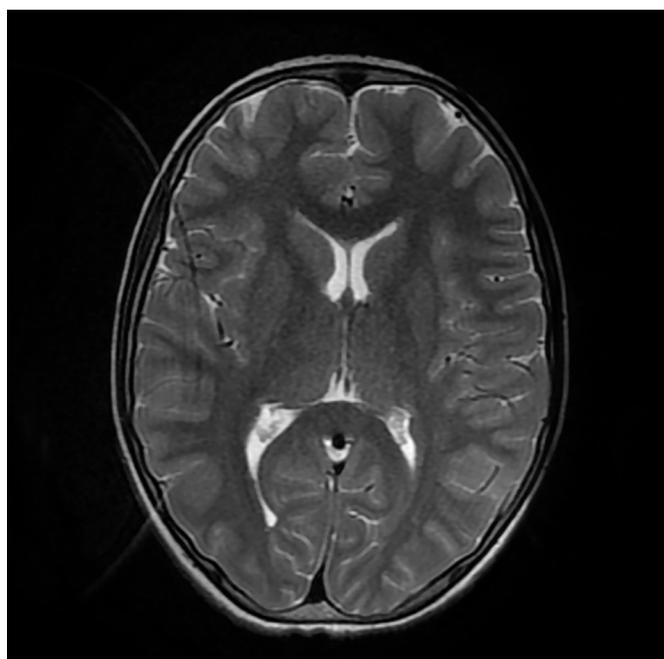


Figure 2. Cranial CT image
CT: Computed tomography

Antidiuretic hormone and B-type natriuretic peptide (BNP) levels could not be evaluated. Consultations from infectious diseases, endocrinology, and child psychiatry clinics did not suggest an underlying systemic or psychiatric disease.

The initial serum Na level of the patient upon admission was 124 mmol/L. At the 6th hour, the level had dropped to 116 mmol/L prior to transfer to the PICU. Upon PICU admission, the Na was 126 mmol/L, increasing to 129 mmol/L at the 12th hour and 131 mmol/L at the 24th hour. Electrolytes and urine output were monitored every 6 hours throughout the correction process. Care was taken to avoid rapid correction to prevent cerebral edema, and the correction was completed without complications.

The patient was started on 3% hypertonic saline fluid therapy. During follow-up, electrolyte values gradually improved, and clinical status stabilized. On the 3rd day of hospitalization, electrolyte balance was restored, and the patient was transferred to the relevant ward on the 4th day. In the social history evaluation performed before discharge, it was learned that the patient performed this behavior within the scope of a challenge spread in the digital environment and did not have a history of psychiatric illness. After an informative interview with the family, the patient was referred to the pediatric adolescent mental health and diseases outpatient clinic, to address relationships and social media usage habits.

Case 2: Aspiration and Cardiac Arrest During Food Challenge

An 11-year-old boy with no known systemic, neurologic or developmental disease had a sudden cardiac arrest due to aspiration during a hamburger eating contest with a group of friends. Cardiopulmonary resuscitation was performed immediately after the arrest, which was witnessed at the scene. He was intubated and admitted to the PICU.

On admission to intensive care unit, GCS was 3; spontaneous respiration was absent, pupils were dilated and fixed, and there was no response to painful stimuli. Vital signs were peak heart rate 100/min, blood pressure 80/40 mmHg, and body temperature 36 °C. On arrival, arterial blood gas analysis indicated: pH 6.97, pCO₂ 79.7 mmHg, HCO₃⁻ 12.7 mmol/L, SBE -13.3 mmol/L, and severe respiratory/metabolic acidosis was observed. Dense food residues were observed in the mouth during intubation (Figure 3).

Inotropic treatment was started, but hypotension persisted. Cranial and thoracic CT imaging performed in the emergency department revealed no intracranial pathology; thoracic CT showed infiltrative findings compatible with aspiration pneumonia (Figure 4). Food residues were aspirated from the tracheobronchial system by bronchoscopy: white blood cell 13.500/μL, hemoglobin 16.5 g/dL, platelet 212.000/μL; Na⁺ 153 mmol/L, potassium 6.0 mmol/L, Cl⁻ 106 mmol/L,

Ca²⁺ 10.9 mg/dL, P 9.7 mg/dL, Mg²⁺ 3.0 mg/dL, glucose 198 mg/dL. Cefotaxime and clindamycin were started as empirical antibiotic treatment.

In cardiac examination, normal sinus rhythm was observed on electrocardiography; no pathologic waveform was observed. Cardiac biomarkers were measured as follows: troponin 50 ng/L, creatine kinase (CK)-muscle brain 10.7 μg/L, CK 342 U/L, and pro-BNP 282 pg/mL. Echocardiography showed normal cardiac function. Neuron-specific enolase and S100-B, which are serum neurologic markers with diagnostic value for hypoxic brain injury, were requested but could not be studied. EEG was planned but could not be performed. Brain MRI was planned but could not be performed due to hemodynamic instability.



Figure 3. Food residue observed in the mouth during intubation

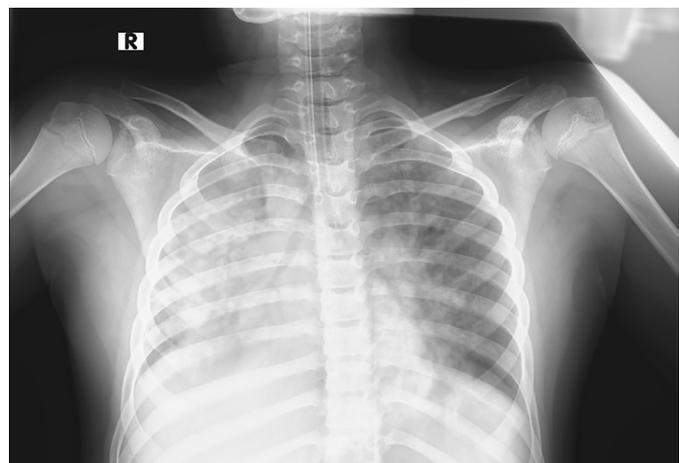


Figure 4. Bilateral perihilar infiltrations and bronchial airway filling on posterior-anterior chest radiograph images

The patient presented with a GCS score of 3, with absent brainstem reflexes. Due to the unstable clinical condition, advanced neuroimaging (MRI, EEG) could not be performed. Neurological deterioration was attributed to hypoxic-ischemic encephalopathy. Supportive care was initiated, including hemodynamic stabilization and fluid-electrolyte management. Despite all supportive efforts, neurological recovery could not be achieved.

Renal impairment secondary to hypoxic injury was suspected. With decreased urine output, intravenous furosemide was administered, and an adequate diuretic response was achieved. Pediatric nephrology was consulted, and close monitoring of renal function and blood pressure within physiological ranges was recommended. Despite the increase in creatinine from 0.97 mg/dL at admission to 2.51 mg/dL at the last follow-up, urine output remained sufficient and fluid-electrolyte balance was preserved. Although severe lactic acidosis was present, continuous renal replacement therapy (CRRT) was not indicated after nephrology reassessment; however, preparations for prompt CRRT initiation were made in case of clinical deterioration.

Despite all medical and supportive treatments in intensive care unit follow-up, there was no neurologic response, so the patient was considered deceased on the third day, with cardiopulmonary and neurologic findings. There was no family history of developmental delay, dysphagia, epilepsy or other neurologic diseases. The incident was witnessed during an "eating contest" he participated in with a group of friends in his social circle, and no information on the use of toxic agents or substances was found in the anamnesis.

Discussion

Two cases are presented showing that social media-based challenging behaviors may result in serious morbidity and even mortality in adolescents. Adolescence is a period in which identity development continues, peer approval is at the forefront, and impulse control mechanisms are not yet fully developed. These psychosocial characteristics may lead individuals to high-risk behaviors for the sake of social acceptance or digital popularity.³ In both cases, severe clinical manifestations developed as a direct result of these risky digital behaviors (Table 1).

In the first case, hyponatremia and related neurologic symptoms were observed in a 12-year-old boy who participated in a water drinking challenge with group pressure. He presented with confusion and convulsions, and laboratory tests revealed severe hyponatremia (Na: 116 mmol/L). After electrolyte balance was restored, the patient recovered completely and was discharged. This case shows that social media-based "drinking water" challenges can lead to serious complications such as hyponatremia, which can be life-threatening within a short period. In this case, only the external factor of social media was found to be decisive.

In the second case, we report an 11-year-old boy who aspirated after a hamburger eating contest with his peers, and presented with cardiac arrest. At presentation, the patient had a GCS of 3, no spontaneous breathing, and was in a deep coma with fixed-dilated pupils. Blood gas analysis revealed severe metabolic acidosis (pH: 6.97) and marked lactic acidosis. The hemodynamic instability that persisted despite inotropic treatment indicated severe deterioration in organ perfusion, and the patient died on the 3rd day in the intensive care unit. This case illustrates that hypoxic-ischemic encephalopathy and respiratory failure resulting in fatal complications may occur as a result of digital challenges.

Table 1. Comparison of clinical and laboratory characteristics of two adolescent patients who developed after digital challenge

| | Case 1: Hyponatremia | Case 2: Aspiration |
|----------------------|---|--|
| Age/gender | 12 years/male | 11 years/male |
| Triggering event | Peer pressure challenge, ingestion of 4-5 liters of water | Bet with peers, hamburger eating contest |
| Reason for admission | Confusion, seizure | Cardiac arrest after aspiration |
| GCS | 10 | 3 |
| Neurological status | Altered mental status, convulsion | Areflexic, fixed and dilated pupils |
| Laboratory findings | Na: 116 mmol/L, Cl: 80 mmol/L | pH: 6.97, pCO ₂ : 79.7 mmHg, HCO ₃ : 12.7 mmol/L, SBE: -13.3 |
| Treatment | 3% NaCl, fluid management, ceftriaxone, acyclovir | Cefotaxime, clindamycin, inotropic support |
| Imaging | Brain CT, cranial MRI, EEG | Chest X-ray, thorax CT, brain CT |
| Procedures | Lumbar puncture | Bronchoscopy |
| Hospital course | Electrolyte balance achieved on day 3, transferred to ward on day 4 | Deceased on day 3 in PICU |
| Clinical outcome | Discharged in full recovery | Exitus |

GCS: Glasgow Coma score, Na: Sodium, Cl: Chloride, CT: Computed tomography, MRI: Magnetic resonance imaging, EEG: Electroencephalography, PICU: Pediatric intensive care unit, SBE: Standard base excess

In recent years, there has been an increase in dangerous challenges that spread rapidly through social media platforms. Behaviors such as “choking game”, “Benadryl challenge”, “salt and ice game”, “swallowing cinnamon” and “eating laundry capsules”, especially supported by video content, reach large masses and are rapidly spreading among adolescents.⁴ Such challenges are known to cause life-threatening complications such as severe neurological damage, hyponatremia, aspiration, and cardiac arrest.

Such digitally oriented behaviors point to a systemic and social problem, that cannot be explained only by individual psychiatric disorders. Social media interactions represent a new public health problem in child and adolescent health. Pediatricians should consider digital defiance behaviors as a differential diagnosis in adolescent patients presenting with unexplained symptoms or atypical clinical pictures. During the clinical evaluation, not only physical findings but also behavioral and social histories such as social media usage habits, peer relationships, exposure to digital content, and family communication style should be questioned in detail.⁴

Monitoring of metabolic parameters is of great importance in intensive care processes. Especially in the second case, blood gas monitoring played a critical role in treatment planning in terms of ventilation failure, tissue perfusion impairment, and hemodynamic instability management (Table 2). As emphasized in the literature, arterial blood gas analysis performed at frequent intervals in similar severe cases is an important tool in directing the effectiveness of the treatment process and prognosis prediction.⁵

Media literacy programs in schools should inform both children and parents and make students aware of the risks they may face in the digital world. These programs can raise awareness among children and adolescents about harmful or manipulative content on the internet. Social media platforms should also take responsibility in this process.

Systems need to be strengthened and ethical mechanisms developed to prevent the spread of risky content. These technological measures can play an important role in protecting groups of children in particular. The presented cases clearly demonstrate that social interactions on digital platforms can lead to life-threatening and even fatal consequences in adolescents. This situation shows that risky behaviors exposed to digital media are a public health problem that needs to be addressed not only at the individual level but also at the societal level. In this context, it is critical that health professionals, families, educators, and digital content providers cooperate using a multidisciplinary approach.

In conclusion, digital challenges during adolescence may pose serious risks to child and adolescent health. These facts suggest that digital media may create a new public health problem at the societal level. Therefore, health professionals, parents, educators, digital platform providers, and politicians should act in cooperation. Finally, social media platforms need to increase ethical and technological measures for content moderation and user safety. This is a vital step in protecting child and adolescent health in the digital age.

Table 2. Changes in metabolic and respiratory parameters over time in adolescent patients hospitalized in intensive care unit due to aspiration

| Time | Vital signs | pH | PCO ₂ (mmHg) | HCO ₃ ⁻ (mmol/L) | Lactate (mmol/L) (Normal <2 mmol/L) | Ventilation status | Clinical interpretation |
|-----------------------------------|--------------------------|------|-------------------------|--|-------------------------------------|--------------------|---|
| Emergency admission | Hypotensive, bradycardic | 6.68 | 49.5 | 4.7 | 20.0 | Intubated | Severe mixed acidosis (metabolic + respiratory), elevated lactate indicates tissue hypoperfusion. |
| 6 th hour | Hypotensive, bradycardic | 7.00 | 66.7 | 12.5 | 5.7 | Intubated | Respiratory acidosis has worsened; metabolic correction is insufficient; hemodynamic instability persists. |
| 1 st day | Hypotensive, bradycardic | 7.11 | 47.1 | 13.8 | 5.4 | Intubated | Partial improvement in pH and HCO ₃ ⁻ levels; slow decrease in lactate suggests ongoing poor tissue perfusion. |
| 2 nd day | Hypotensive, bradycardic | 7.09 | 56.8 | 14.5 | 3.7 | Intubated | Persistent metabolic acidosis and elevated lactate levels suggest ongoing tissue hypoperfusion. |
| 2 nd day clinical note | - | - | - | - | - | - | Despite intensive inotropic support, cardiovascular stability could not be achieved; suggests refractory shock. Arterial blood gas monitoring was critical for treatment and prognosis. |

Ethics

Informed Consent: Informed consent for participating in the study was obtained from the parents of the patient.

Footnotes

Authorship Contributions

Surgical and Medical Practices: K.E.A., F.B., Concept: K.E.A., F.B., Design: K.E.A., F.B., Data Collection or Processing: K.E.A., F.B., Analysis or Interpretation: K.E.A., F.B., Literature Search: K.E.A., F.B., Writing: K.E.A., F.B.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

References

1. Wang ML, Togher K. Health misinformation on social media and adolescent health. *JAMA Pediatr.* 2024;178:109-10.
2. Casey BJ, Jones RM, Hare TA. The adolescent brain. *Ann N Y Acad Sci.* 2008;1124:111-26.
3. Crone EA, Konjin EA. Media use and brain development during adolescence. *Nat Commun.* 2018;9:588.
4. Dacka M. Social media challenges among adolescents - unconscious danger or peer pressure? Dangerous consequences of modern adolescents' games. *Psychiatr Psychol Klin.* 2024;24:79-88.
5. Melanson SE, Szymanski T, Rogers SO, Jarolim P, Frenzl G, et al. Utilization of arterial blood gas measurements in a large tertiary care hospital. *Am J Clin Pathol.* 2007;127:604-9.



When the Pressure Is Not High: A Case of PRES in a Normotensive Child

Basınç Yüksek Değilken: Normotansif Bir Çocukta PRES Olgusu

© Azie Jumaatul Adawiyah Binti Nabir^{1,2}, © Assyifaa Binti Nik Mazian^{3,4}, © Aliyyah Mohammad Khuzaini^{1,2}

¹Universiti Sains Islam Malaysia Faculty of Medicine and Health Sciences, Department of Paediatrics, Nilai, Malaysia

²Hospital Ampang, Clinic of Paediatrics, Ampang, Malaysia

³Universiti Sains Islam Malaysia Faculty of Medicine and Health Sciences, Department of Radiology, Nilai, Malaysia

⁴Hospital Ampang, Clinic of Radiology, Ampang, Malaysia

Abstract

Posterior reversible encephalopathy syndrome (PRES) is a clinico-radiological syndrome due to disturbances in the blood-brain barrier that cause vasogenic oedema. It has been postulated that PRES is caused by disturbances of cerebral autoregulation secondary to acute hypertension, and this is often seen in patients with acute kidney injury. We report a case of PRES in a 6-year-old girl with severe polyserositis and acute kidney injury. She had no neurological symptoms at presentation, and was covered initially for sepsis despite no positive culture. The autoimmune screen was negative. On day 13 of admission, she developed right-sided focal seizures. Clinical examination showed upper motor neuron signs. Pupils were reactive, and consciousness was intact. A contrast-enhanced computed tomography of the brain suggested vasogenic oedema with prominent sulci and ventricles. Subsequently, magnetic resonance imaging of the brain confirmed the diagnosis. She was started on intravenous phenytoin, and no further seizures were observed. A clinical examination one week later showed normal neurological findings. Consequently, phenytoin was gradually tapered, and she remains well with no sequelae. Symptoms of PRES are typically preceded by hypertension or pronounced fluctuations in blood pressure. There are limited reports of PRES in pediatric patients with normal blood pressure. Despite clinical suspicion of an autoimmune disorder, this patient did not fulfil the criteria for systemic lupus erythematosus, and all autoimmune markers were negative. She was later subsequently diagnosed with diffuse large B-cell lymphoma and succumbed to the disease one year later. Furthermore, this patient demonstrates frontal lobe involvement and microhemorrhages, which are absent in adult cohorts but are consistent with previous reports in children with PRES. The clinical and radiological manifestations of PRES remain elusive in the pediatric population and warrant further research.

Öz

Posterior reversibl ensefalopati sendromu (PRES), kan beyin bariyerindeki bozuklukların vazojenik ödeme neden olduğu bir klinik-radyoloji sendromudur. PRES'in akut hipertansiyon nedeniyle serebral otoregülasyonundaki bozukluklardan kaynaklandığı ve bunun sıklıkla akut böbrek hasarı olan hastalarda görüldüğü öne sürülmüştür. Bu çalışmada şiddetli poliseroz ve akut böbrek hasarı olan 6 yaşındaki bir kız çocuğunda PRES olgusu sunulmaktadır. Hasta başvuru sırasında nörolojik semptom göstermiyordu ve kültür sonucu pozitif olmamasına rağmen başlangıçta sepsis tedavisi gördü. Otoimmün tarama negatifti. Hastaneye yatışının 13. gününde sağ taraflı fokal nöbetler gelişti. Klinik muayenede üst motor nöron bulguları saptandı. Göz bebekleri reaktif ve bilinç bozukluğu yoktu. Kontrastlı bilgisayarlı tomografi bulguları, belirgin sulkus ve ventriküller ile birlikte vazojenik ödem olduğunu gösterdi. Daha sonra yapılan manyetik rezonans görüntüleme ile tanı doğrulandı. Hastaya intravenöz fenitoin tedavisi başlandı ve başka nöbet görülmedi. Bir hafta sonra yapılan klinik muayenede nörolojik açıdan normal olduğu görüldü. Sonuç olarak, fenitoin dozu kademeli olarak azaltıldı. Hasta herhangi bir sekel kalmadan iyi durumda idi. PRES semptomları genellikle hipertansiyon veya belirgin kan basıncı dalgalanmaları ile başlar. Ancak, bu hasta hastanede kaldığı süre boyunca normotansif kaldı. Otoimmün bozukluk şüphesi olmasına rağmen, bu hasta sistemik lupus eritematozus kriterlerini karşılamadı ve tüm otoimmün belirteçler negatifti. Daha sonra yaygın B hücreli lenfoma teşhisi kondu ve bir yıl sonra hayatını kaybetti. Ayrıca, bu hastada frontal lob tutulumu ve mikrokanamalar da görülmektedir. Bu bulgular yetişkin kohortlarında görülmemekle birlikte, PRES'li çocuklarda daha önce bildirilen bulgularla tutarlıdır. PRES'in pediatrik popülasyondaki klinik ve radyolojik belirtileri hala belirsizdir ve daha fazla araştırma yapılması gerekmektedir.

Address for Correspondence/Yazışma Adresi: Aliyyah Mohammad Khuzaini, MD, Universiti Sains Islam Malaysia Faculty of Medicine and Health Sciences, Department of Paediatrics, Nilai, Malaysia; Hospital Ampang, Clinic of Paediatrics, Ampang, Malaysia

E-mail: aliyahkhuzaini@usim.edu.my **ORCID ID:** orcid.org/0000-0002-6127-7180

Received/Geliş Tarihi: 17.06.2025 **Accepted/Kabul Tarihi:** 12.09.2025 **Epub:** 25.02.2026 **Publication Date/Yayınlanma Tarihi:** 01.04.2026

Cite this article as: Binti Nabir AJA, Binti Nik Mazian A, Mohammad Khuzaini A. When the pressure is not high: a case of PRES in a normotensive child.

J Pediatr Emerg Intensive Care Med. 2026;13(1):62-8



©Copyright 2026 The Author(s). Published by Galenos Publishing House on behalf of Society of Pediatric Emergency and Intensive Care Medicine. This is an open access article under the Creative Commons Attribution-Attribution-NonCommercial 4.0 (CC BY-NC 4.0) International License.

Abstract

Keywords: Posterior reversible encephalopathy syndrome, magnetic resonance imaging, posterior leukoencephalopathy syndrome

Öz

Anahtar Kelimeler: Posterior reversibl ensefalopati sendromu, manyetik rezonans görüntüleme, posterior lökoensefalopati sendromu

Introduction

Posterior reversible encephalopathy syndrome (PRES) is a rare clinico-radiological condition that may occur in adult and pediatric patients.¹ It was first described by Hinchey et al.² in 1996 as a reversible neurological condition presenting with headache, altered consciousness, and seizures, associated with white matter oedema on radiological imaging. The exact mechanism of PRES is still not fully understood.³ However, the postulated mechanism underlying it involves perturbed cerebrovascular autoregulation and endothelial dysfunction, resulting in vasogenic oedema that most commonly affects the parieto-occipital white matter.³

The common precipitating factors among pediatric patients include hypertension, renal disease, systemic infection, autoimmune conditions, and oncological disease or immunosuppressive therapy.^{1,4} It has been increasingly recognized in the pediatric population, which has prompted growing interest in its pathophysiology, presentation, and management.⁴ Management of PRES is supportive and involves treating the underlying cause. Despite its typically reversible nature, delayed recognition and treatment can lead to irreversible neurological damage or fatal outcomes, occurring in as many as 16% of cases.²

Case Report

A previously healthy 6-year-old girl presented with focal seizures on day 14 of admission to the intensive care unit (ICU). She initially presented with respiratory distress, serositis, and multi-organ failure, requiring mechanical ventilation. Neuroimaging revealed vasogenic oedema consistent with PRES. Informed consent was obtained from the patient's parents.

A 6-year-old girl of Mediterranean origin presented to the emergency department with a three-month history of breathlessness, lethargy, and constipation. Over the preceding year, she had experienced weight loss, reduced appetite, polyarthralgia, and intermittent vasculitic rashes, but had not sought medical attention due to financial constraints. She was born at term as part of a monochorionic monoamniotic twin pair to consanguineous parents. Her twin sister had been diagnosed with systemic lupus erythematosus at the age of five, and there was a strong family history of autoimmune diseases and malignancies.

On examination, she was cachectic and in severe respiratory distress, requiring immediate intubation. She was hypoxic, pale, and exhibited muscle wasting. Respiratory assessment revealed bilateral crepitations and reduced air entry. Abdominal examination showed gross ascites and a large palpable mass. Neurologically, she was conscious with normal tone, power, and reflexes; cranial nerve function was intact. Notably, she was normotensive and had normal renal function at presentation.

She was intubated, and bilateral chest drains and peritoneal drains were inserted. Contrast-enhanced computed tomography (CECT) of the thorax, abdomen, and pelvis revealed bilateral adnexal masses with features suggestive of ovarian malignancy, including omental caking, peritoneal thickening, and lymphadenopathy. Additional findings included bilateral pleural effusions, ascites, and enlarged kidneys. She was treated for serositis complicated by multi-organ failure and investigated for an underlying malignancy or an autoimmune disorder. Despite extensive imaging and fluid analysis, cytology and immunophenotyping were inconclusive, and autoimmune screening was negative (Tables 1 and 2). Surgical exploration of the abdominal mass was not performed because the patient was critically ill.

On day 13 of ICU admission, she developed focal tonic seizures affecting the right upper limb that lasted one hour and necessitated loading and maintenance doses of phenytoin. During this time, she received mechanical ventilation without haemodynamic support. Neurological examination showed bilateral hypertonicity of the lower limbs, hyperreflexia, and clonus, while the pupils remained reactive and equal. Neurological examination of the upper limbs was normal. Her level of consciousness could not be reliably assessed because she was intubated and sedated.

At this time, her blood pressure remained between the 50th and 95th percentiles, with no marked variability. Trends in her systolic and diastolic blood pressure are shown in Figure 1.

At this point, her medications included intravenous meropenem, dexmedetomidine, fentanyl, and clonidine. She had acute kidney injury with hyperkalemia and hypophosphatemia a week prior to the seizure; the kidney injury was attributed to tumor lysis syndrome. However, her renal profile and electrolyte levels normalized two days prior to the seizure. There was no evidence of other end-organ failure at this point. All cultures were sterile. Autoimmune

Table 1. Results of pleural and peritoneal fluid

| Parameter | Pleural fluid | Peritoneal fluid | Remarks |
|---|----------------------|-------------------|--|
| pH | 7.8 | | Serum: Protein: 70.13 LDH: 2663 |
| Total protein (g/L) | 40.84 | N/A | |
| LDH (U/L) | 3861 | | |
| Gram stain | Nil | Nil | |
| Appearance | Cloudy | Slightly cloudy | |
| WBC (x10 ⁶ /L) | 6965 | 2419 | |
| RBC (x10 ⁶ /L) | 12000 | 5000 | |
| Mononuclear cell (x10 ⁶ /L) | 6037 | 2264 | |
| Polymorphonuclear (x10 ⁶ /L) | 928 | 155 | |
| Total count WBC (x10 ⁶ /L) | 7800 | 2444 | |
| Culture and sensitivity | No growth | No growth | |
| AFB | Negative | Negative | |
| Mycobacterium C&S | No growth | No growth | |
| Cytology | No atypical cells | No atypical cells | Blood tap sample. 7% cluster of small sized B cells lacking surface light chains. |
| Immunophenotyping | Inconclusive results | | |

N/A: Not applicable, Nil: None detected, LDH: Lactate dehydrogenase, WBC: White blood cell, RBC: Red blood cell, AFB: Acid fast bacilli, C&S: Culture and sensitivity

Table 2. Investigation results

| Investigations | Results | Reference range | Interpretation |
|--------------------------------------|-------------|-----------------|----------------|
| Complement C3 | 1.34 g/L | 0.82-1.85 g/L | Normal |
| Complement C4 | 0.24 g/L | 0.15-0.53 g/L | Normal |
| ANA screening and immunofluorescence | Negative | | |
| Anti-mycoplasma antibody | Negative | | |
| Coombs test | Negative | | |
| Antiphospholipid antibody panel | Negative | | |
| ENA | Negative | | |
| Rheumatoid factor | Negative | | |
| Immunoglobulin level | | | |
| Immunoglobulin G | 3.87 g/L | 0.52-16.31 | Low |
| Immunoglobulin A | 2.86 g/L | 0.21-2.82 | Elevated |
| Immunoglobulin M | 0.99 g/L | 0.47-2.4 | Normal |
| Alpha fetoprotein | 2.457 ng/mL | 0-8.1 | Normal |
| Beta human chorionic gonadotropin | <2 mIU/mL | 0-6 | Normal |
| CA-125 | 1 300 U/mL | 0-35 | Elevated |
| CEA | <0.5 ng/mL | 0-5.1 | Normal |
| Parathyroid hormone | 3.04 pmol/L | 1.58-6.03 | Normal |
| 25-hydroxyvitamin D | 17.63 ng/mL | 20-40 | Low |
| Procalcitonin | 17.05 ng/mL | 0.03-0.1 | Elevated |

ANA: Antinuclear antibody, ENA: Extractable nuclear antigen, CA: Cancer antigen, CEA: Carcinoembryonic antigen

and viral screenings were negative. An electroencephalogram was not available in our setting at the time. A CECT scan of the brain demonstrated white matter hypodensities in the bilateral superior fronto-parietal lobes with effacement of the adjacent sulci, suggesting vasogenic oedema (Figure 2A-B).

Magnetic resonance imaging (MRI) of the brain was performed the next day. The MRI demonstrated symmetrical abnormal signal intensities in the bilateral superior fronto-parietal lobes, which were hypointense on T1-weighted images and hyperintense on T2/fluid-attenuated inversion recovery (FLAIR) sequences (Figure 3A-C). No cortical thinning or

enhancement was observed after gadolinium administration (Figure 3D).

Diffusion-weighted imaging and apparent diffusion coefficient mapping showed facilitated diffusion, consistent with vasogenic oedema (Figure 3E-F). Additionally, multiple foci of blooming artefacts were observed on the gradient-recalled echo sequence within adjacent sulci, more pronounced on the right than on the left, suggestive of microhemorrhages (Figure 3G). These changes involved the subcortical and juxtacortical regions, with effacement of the grey-white matter junction (Figure 3H). The brainstem, cerebellum, and

spinal cord appeared normal; no hydrocephalus, midline shift, or venous sinus thrombosis were detected.

Anti-epileptic medication was initiated and successfully tapered off within four weeks. A week later, she was extubated and had a normal neurological examination. No follow-up brain imaging was performed due to financial constraints. She received intravenous hydrocortisone 4 mg/kg four times daily for two weeks, followed by a weaning regimen of oral prednisolone for the subsequent two weeks. During admission, she received multiple courses of antibiotics, as shown in Table 3. Consequently, a repeat CECT of the abdomen showed a significant reduction in the size of the adnexal mass. Thus, she was discharged after six weeks and followed up by the pediatric rheumatology team.

Upon discharge, her neurological examination was normal, with no motor or sensory deficits. She regained full independence in her activities of daily living and had no difficulties with feeding, urination, or bowel movements. A year later, she

presented again with a left lumbar mass and constitutional symptoms, and was eventually diagnosed with diffuse large B-cell lymphoma (DLBCL). She underwent multiple courses of chemotherapy but succumbed to the disease's aggressive nature; throughout the illness she exhibited no neurological symptoms. This case illustrates an atypical presentation of PRES in a critically ill child with a suspected malignancy who had no initial hypertension, highlighting the importance of early neuroimaging for unexplained seizures.

Discussion

We report a case of PRES in a pediatric patient despite normal blood pressure and resolved acute kidney injury. It is an increasingly recognized clinico-radiological entity in the pediatric population, characterized by diverse etiologies, variable clinical presentations, and potential reversibility with timely intervention.^{1,5}

As outlined in the introduction, the pathophysiology of PRES is thought to involve impaired cerebrovascular autoregulation.^{1,2} Impaired cerebrovascular autoregulation, combined with endothelial dysfunction, is considered the primary pathophysiological mechanism leading to transient vasogenic edema of the brain parenchyma.^{1,2} In this model, severe hypertension exceeds the limits of autoregulation, overwhelming endothelial capacity and impairing compensatory vasoconstriction. The resulting hyperperfusion allows plasma and macromolecules to leak from cerebral vessels, producing edema.^{1,6,7}

While hypertension is a well-established trigger, particularly in the context of renal disease, PRES can also arise in normotensive or hypotensive states, as illustrated by the case reported by Adhikari et al.⁵ in which hypovolemic shock was the precipitating factor. In our case, the patient developed PRES during a prolonged ICU stay, with contributing factors including systemic

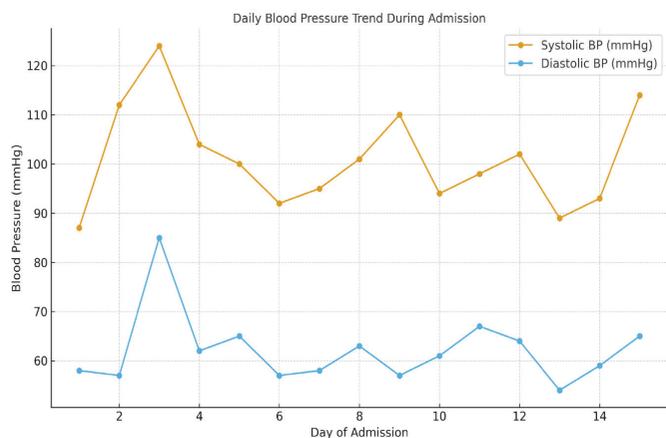


Figure 1. Blood pressure trend during PICU stay
PICU: Pediatric intensive care unit, BP: Blood pressure

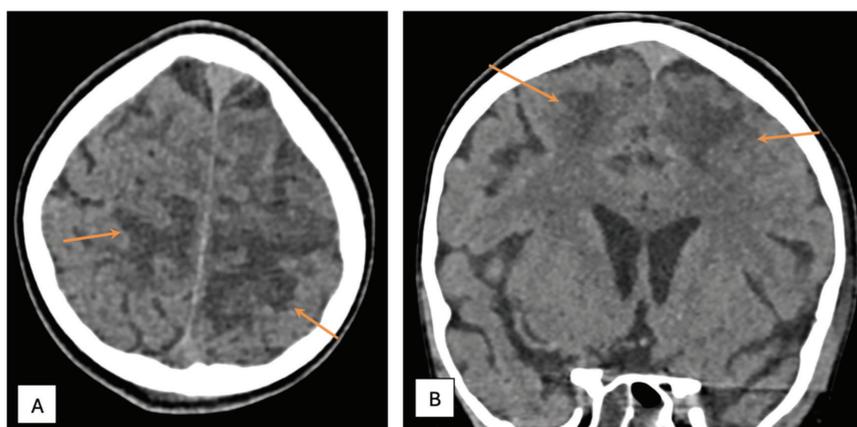


Figure 2. Contrast-enhanced CT brain in axial (A) and coronal (B) views showed symmetrical white matter hypodensities at bilateral superior fronto-parietal lobes (orange arrows). The adjacent sulci are effaced

CT: Computed tomography

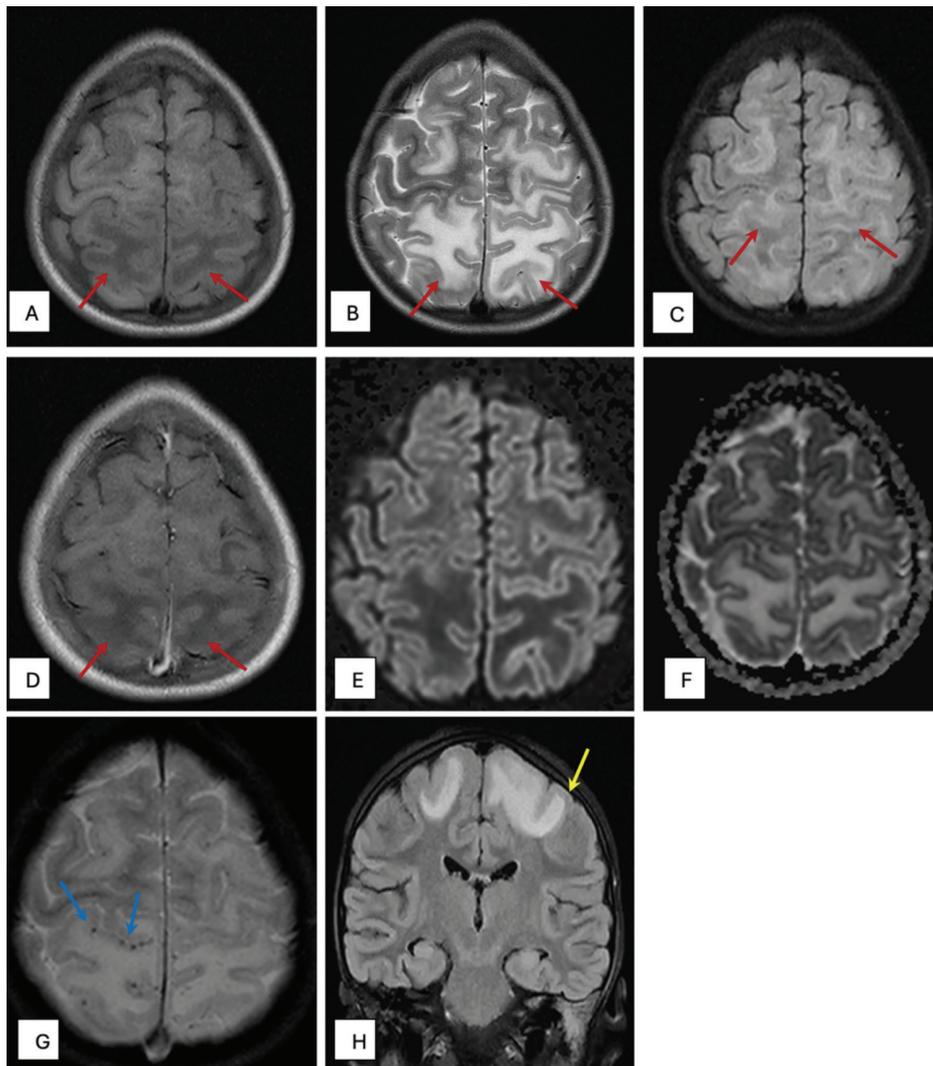


Figure 3. MRI brain in axial views revealed symmetrical white matter abnormal signal intensities at bilateral fronto-parietal lobes (red arrows), which returned hypointense signal on T1 (A), hyperintense on T2 (B), not suppressed on FLAIR (C) and no enhancement post contrast (D). ADC/DWI sequences (E,F) showed no restricted diffusion to suggest acute infarct. Blooming artefacts on GRE suggestive of microhaemorrhages were present (blue arrow) (G). The T2 weighted image in the coronal view (H) showed abnormal white matter signal distribution at the juxtacortical and subcortical region (yellow arrow)

MRI: Magnetic resonance imaging, FLAIR: Fluid-attenuated inversion recovery, ADC: Apparent diffusion coefficient, DWI: Diffusion-weighted imaging, GRE: Gradient-recalled echo

| Table 3. Antibiotic summary | | | |
|-----------------------------|--|------------------------|-----------------|
| Antibiotic | Dose | Mode of administration | Duration (days) |
| Ceftriaxone | 50 mg/kg twice daily | Intravenous | 1 day |
| Azithromycin | 15 mg/kg once daily | Intravenous | 1 day |
| Piperacillin-tazobactam | 112.5 mg/kg three times daily | Intravenous | 2 days |
| Meropenem | 20 mg/kg twice daily | Intravenous | 7 days |
| Vancomycin | 25 mg/kg three times daily | Intravenous | 7 days |
| Fluconazole | 12 mg/kg once daily | Intravenous | 5 days |
| Ceftazidime | 25 mg/kg three times daily | Intravenous | 5 days |
| Amikacin | 25 mg/kg on day 1 then 18mg/kg twice daily | Intravenous | 5 days |
| Ampicillin-sulbactam | 200 mg/kg+100mg/kg three times daily | Intravenous | 4 days |
| Linezolid | 10 mg/kg three times daily | Intravenous | 3 days |
| Nystatin | 250.000 units three times daily | Oral | 9 days |

infection, mechanical ventilation, and preceding acute kidney injury. This aligns with the literature, in which critical illness and systemic inflammation are increasingly recognized as potential contributors to PRES pathogenesis, alongside renal dysfunction, autoimmune diseases, cytotoxic agents, and sepsis.⁶⁻¹⁰

Beyond hypertension, endothelial dysfunction is a critical contributing factor.^{6,8,11} This can stem from a direct toxic effect of immunosuppressive or chemotherapeutic agents, or from conditions involving systemic inflammation or sepsis.^{8,9,11} In some cases of chronic anemia, rapid, large-volume blood transfusions have been hypothesized to induce PRES by disrupting vascular autoregulation, resulting in hyperperfusion and acute vascular endothelial dysfunction, which can cause cerebral damage.¹² Other potential factors include reperfusion injury and, in some cases, microthrombosis associated with immunosuppressive therapy, such as systemic corticosteroids, which this patient was receiving.^{1,13,14}

Given the multifactorial nature of PRES in critically ill patients, as seen in our case, accurate and timely diagnosis is essential, particularly via neuroimaging.^{3,4,6} MRI is the preferred modality because its sensitivity and specificity for detecting characteristic vasogenic edema, particularly in posterior subcortical regions, are superior to those of CT scans.

The hallmark radiological feature on MRI is white matter edema, which typically appears as hyperintense signal on T2-weighted and FLAIR sequences, most commonly involving the occipital and parietal lobes. However, pediatric PRES frequently involves atypical MRI findings in regions beyond the posterior circulation, including the frontal and temporal lobes, cerebellum, brainstem, basal ganglia, thalamus, and corpus callosum.¹⁵ Some authors suggest that these "atypical" features in adults may be considered "typical" in children.^{6,7,15}

This patient's MRI showed vasogenic edema and microhemorrhages. Microhemorrhages are increasingly reported in this condition and are believed to result from blood-brain barrier disruption due to impaired cerebral autoregulation, often triggered by acute elevations in systemic blood pressure.^{6,8} This leads to hyperperfusion, increasing hydrostatic pressure within cerebral capillaries and resulting in leakage of fluid into the brain parenchyma (vasogenic edema). Subsequently, this leads to the extravasation of red blood cells, which appears as petechial hemorrhages.¹¹ Unfortunately, follow-up imaging was not available for this patient, rendering confirmation of complete resolution of PRES difficult.

PRES in DLBCL arises via two pathways: as a paraneoplastic or metabolic presentation at diagnosis (notably with hypercalcemia and labile blood pressure) and as a toxicity of lymphoma therapy, most often during or shortly after chemotherapy initiation.¹⁶⁻¹⁸ This patient developed PRES

as the first manifestation of DLBCL, without hypertension or prior exposure to cytotoxic chemotherapy, similar to a reported case of DLBCL presenting with PRES in an adult with hypercalcemia and no hypertension.¹⁷ Corticosteroid therapy and acute kidney injury were likely contributing factors, both recognized risk factors for endothelial dysfunction.

As highlighted in pediatric and oncologic cohorts, PRES may occur in normotensive patients and can precede the diagnosis of malignancy. In similar cases, clinicians should maintain a high index of suspicion for underlying hematological disease and pursue early, aggressive investigation to enable timely diagnosis and management.

Conclusion

PRES may rarely present as initial manifestation of an underlying hematologic malignancy in children. This case emphasizes the need for thorough evaluation and close observation in pediatric patients with PRES who lack an obvious precipitating factor. Early identification of the underlying cause may alter management and improve outcomes.

Ethics

Informed Consent: Informed consent was obtained from the patient's parents.

Footnotes

Authorship Contributions

Concept: A.M.K., Design: A.B.N.M., A.M.K., Data Collection or Processing: A.J.A.B.N., A.B.N.M., A.M.K., Analysis or Interpretation: A.J.A.B.N., A.B.N.M., A.M.K., Literature Search: A.J.A.B.N., A.B.N.M., A.M.K., Writing: A.J.A.B.N., A.M.K.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

References

1. Fugate JE, Claassen DO, Cloft HJ, Kallmes DF, Kozak OS, et al. Posterior reversible encephalopathy syndrome: associated clinical and radiologic findings. *Mayo Clin Proc.* 2010;85:427-32.
2. Hinchey J, Chaves C, Appignani B, Breen J, Pao L, et al. A reversible posterior leukoencephalopathy syndrome. *N Engl J Med.* 1996;334:494-500.
3. Siebert E, Bohner G, Endres M, Liman TG. Clinical and radiological spectrum of posterior reversible encephalopathy syndrome: does age make a difference?—A retrospective comparison between adult and pediatric patients. *PLoS One.* 2014;9:e115073.
4. Ghali MGZ, Davanzo J, Leo M, Rizk E. Posterior reversible encephalopathy syndrome in pediatric patients: pathophysiology, diagnosis, and management. *Leuk Lymphoma.* 2019;60:2365-72.

5. Adhikari Y, Bista S, Karmacharya S, Upadhaya Regmi B, Marasini A, et al. Posterior reversible encephalopathy syndrome in a child following hypovolemic shock: a case report. *Ann Med Surg (Lond)*. 2023;85:5682-5.
6. Chen TH, Lin WC, Tseng YH, Tseng CM, Chang TT, et al. Posterior reversible encephalopathy syndrome in children: case series and systematic review. *J Child Neurol*. 2013;28:1378-86.
7. Onder AM, Lopez R, Teomete U, Francoeur D, Bhatia R, et al. Posterior reversible encephalopathy syndrome in the pediatric renal population. *Pediatr Nephrol*. 2007;22:1921-9.
8. Emeksiz S, Kutlu NO, Çaksen H, Alkan G, Yıkılmaz HŞ, et al. Posterior reversible encephalopathy syndrome in children: a case series. *Turk Pediatri Ars*. 2016;51:217-20.
9. Mata-Perera C, López-Álvarez JM, Lorenzo-Villegas DL. Posterior reversible encephalitis syndrome (PRES) in a paediatric patient in the intensive care unit. *Glob J Medical Clin Case Rep*. 2024;11:001-4.
10. Tosun D, Akçay N, Oğur M, Şevketoplu E. A rare cause of encephalopathy in children: pres syndrome. *MNJ*. 2023;10:76-8.
11. Endo A, Fuchigami T, Hasegawa M, Hashimoto K, Fujita Y, et al. Posterior reversible encephalopathy syndrome in childhood: report of four cases and review of the literature. *Pediatr Emerg Care*. 2012;28:153-7.
12. Hanna D, Nada MG, Gohary MM. Posterior reversible encephalopathy syndrome in a known case of beta-thalassemia major after blood transfusion: a case presentation. *Egypt Pediatric Association Gaz*. 2024;72:68.
13. Gupta V, Bhatia V, Khandelwal N, Singh P, Singhi P. Imaging findings in pediatric posterior reversible encephalopathy syndrome (PRES): 5 years of experience from a tertiary care center in India. *J Child Neurol*. 2016;31:1166-73.
14. Siebert E, Spors B, Bohner G, Endres M, Liman TG. Posterior reversible encephalopathy syndrome in children: radiological and clinical findings - a retrospective analysis of a German tertiary care center. *Eur J Paediatr Neurol*. 2013;17:169-75.
15. Habetz K, Ramakrishnaiah R, Raina SK, Fitzgerald RT, Hinduja A. Posterior reversible encephalopathy syndrome: a comparative study of pediatric versus adult patients. *Pediatr Neurol*. 2016;65:45-51.
16. Arzanian MT, Shamsian BS, Karimzadeh P, Kajiyazdi M, Malek F, et al. Posterior reversible encephalopathy syndrome in pediatric hematologic-oncologic disease: literature review and case presentation. *Iran J Child Neurol*. 2014;8:1-10.
17. Patejdl R, Borchert K, Pagumbke H, Benecke R, Grossmann A, et al. Posterior reversible encephalopathy syndrome (PRES): an unusual primary manifestation of a diffuse large B-cell lymphoma. *Clin Neurol Neurosurg*. 2011;113:819-21.
18. Gaddam S, Kodandapani R, Mani N, Jayaraman D, Abirami BN. Posterior reversible encephalopathy syndrome in immunocompromised children - a single-center study from South India. *J Neurosci Rural Pract*. 2024;15:365-9.



Non-invasive Mechanical Ventilation in Children and Newborns: A Bibliometric Analysis Study and Literature Review

Çocuklarda ve Yenidoğanlarda Non-invaziv Mekanik Ventilasyon: Bibliyometrik Analiz Çalışması ve Literatür Taraması

© Sri Martuti, © Annang Giri Moelyo, © Hanum Ferdian, © Sari Dwi Jayanti

Universitas Sebelas Maret Faculty of Medicine, Department of Child Health, Surakarta, Indonesia

Abstract

Non-invasive ventilation (NIV) supports breathing without endotracheal intubation, lowering the risk of airway injury, sedation-related instability, hospital-acquired infections, and ventilator-associated complications. Growth in publications accelerated during and after the coronavirus disease-2019 (COVID-19) pandemic, yet regional representation of evidence remains uneven. Bibliometric synthesis is useful to clarify research structure, influence, collaboration intensity, and unmet scientific priorities in pediatric NIV. To analyze global publication trends, thematic clusters, and research-collaboration networks in pediatric NIV literature from 2013 to 2023. A systematic search of Scopus metadata was performed on July 23, 2024, using TITLE-ABS-KEY (non-invasive AND mechanical AND ventilation AND pediatric) and restricted to English-language publications (2013-2023). A total of 358 records were analyzed using Scopus analytics to assess annual output, author and institutional productivity, country contributions, keyword co-occurrence, and international co-authorship mapping. Frequently cited studies underwent a narrative review to provide clinical-translational context. Of the 358 documents, 276 (77.1%) were research articles and 55 (14.4%) were reviews. Publication output fluctuated between 2013 and 2018, followed by a steep and sustained rise from 2019 to 2023. The most prolific countries were the United States, Canada, and Spain, whereas Southeast Asia contributed a smaller share, highlighting opportunities for expansion in that region. Highly productive authors included Emeriaud G., Jouvett P., and Essouri S. Four major keyword clusters were identified: respiratory insufficiency, mechanical ventilation, continuous positive airway pressure (CPAP)/bronchiolitis, and acute respiratory distress syndrome/extubation failure. Overlay mapping revealed an increasing interest in CPAP, weaning/extubation outcomes, viral

Öz

Non-invaziv ventilasyon (NIV), endotrakeal entübasyon olmadan solunumu destekleyerek hava yolu yaralanması, sedasyonla ilişkili instabilite, hastane kaynaklı enfeksiyonlar ve ventilatörle ilişkili komplikasyon riskini azaltır. Yayın sayısı koronavirüs hastalığı-2019 (COVID-19) dönemi sırasında ve sonrasında hızla artmış olsa da, bölgesel kanıt temsili hala dengesizdir. Bibliyometrik sentez, pediatrik NIV’da araştırma yapısını, etkisini, işbirliği yoğunluğunu ve karşılanmamış bilimsel öncelikleri netleştirmek için yararlıdır. Bu çalışmanın amacı, 2013’ten 2023’e kadar pediatrik NIV literatüründeki küresel yayın eğilimlerini, tematik kümeleri ve araştırma-işbirliği ağlarını analiz etmektir. 23 Temmuz 2024 tarihinde, İngilizce yayınlarla (2013-2023) sınırlandırılmış TITLE-ABS-KEY (non-invasive AND mechanical AND ventilation AND pediatric) kullanılarak Scopus meta verilerinde sistematik bir arama gerçekleştirilmiştir. Scopus analitiği kullanılarak yıllık çıktı, yazar ve kurum verimliliği, ülke katkıları, anahtar kelime eş-ortaklığı ve uluslararası ortak yazarlık haritalaması açısından toplam 358 kayıt analiz edildi. Sıkça atıf yapılan çalışmalar, klinik-çeviri bağlamı açısından anlatımsal incelemeye tabi tutuldu. Üç yüz elli sekiz belgenin 276’sı (%77,1) araştırma makalesi, 55’i (%14,4) ise derlemeydi. Yayın sayısı 2013-2018 yıllarında değişiklik göstermiş, ardından 2019-2023 yıllarında keskin ve sürdürülebilir bir artış yaşanmıştır. En üretken ülkeler Amerika Birleşik Devletleri, Kanada ve İspanya olurken, Güneydoğu Asya’nın katkısı daha az olup bu da bölgesel genişleme fırsatlarını ortaya koymaktadır. En üretken yazarlar arasında Emeriaud G., Jouvett P. ve Essouri S. yer almıştır. Dört ana anahtar kelime kümesi belirlenmiştir: solunum yetmezliği, mekanik ventilasyon, sürekli pozitif hava yolu basıncı (CPAP)/bronşiyolit ve akut solunum sıkıntısı sendromu/ekstübasyon başarısızlığı. Üst üste bindirme haritalaması, 2020-2023 yıllarında CPAP, ventilatörden ayrılma/ekstübasyon sonuçları, viral enfeksiyon (COVID-19) ve mortalite ile ilgili ölçütlere

Address for Correspondence/Yazışma Adresi: Hanum Ferdian, MD, Universitas Sebelas Maret Faculty of Medicine, Department of Child Health, Surakarta, Indonesia

E-mail: lynne06chelin@gmail.com **ORCID ID:** orcid.org/0009-0005-9603-3388

Received/Geliş Tarihi: 27.11.2025 **Accepted/Kabul Tarihi:** 19.01.2026 **Publication Date/Yayınlanma Tarihi:** 01.04.2026

Cite this article as: Martuti S, Moelyo AG, Ferdian H, Jayanti SD. Non-invasive mechanical ventilation in children and newborns: a bibliometric analysis study and literature review. J Pediatr Emerg Intensive Care Med. 2026;13(1):69-78



Abstract

infection (COVID-19), and mortality-related metrics from 2020 to 2023. Pediatric NIV research is expanding, evolving from neonatal oxygenation and interface topics toward broader prognostication, de-escalation safety, and hard clinical outcomes. Underrepresented regions, including Southeast Asia, present clear potential for collaborative research. Future work should standardize criteria for early NIV success and failure and directly compare high-flow nasal cannula with CPAP/non-invasive positive pressure ventilation across diverse pediatric settings.

Keywords: Non-invasive ventilation (NIV), bibliometric, respiratory failure, pediatric intensive care, children

Öz

olan ilginin arttığını ortaya koymuştur. Pediatrik NIV araştırmaları genişlemekte ve yenidoğan oksijenasyonu ve arayüz konularından daha geniş prognoz, tedavinin azaltılmasının güvenliği ve kesin klinik sonuçlara doğru evrimleşmektedir. Güneydoğu Asya dahil olmak üzere yeterince temsil edilmeyen bölgeler, açık bir işbirliği ve araştırma potansiyeli sunmaktadır. Gelecekteki çalışmalar, erken NIV başarı/başarısızlık kriterlerini standartlaştırmalı ve çeşitli pediatrik ortamlarda yüksek akımlı nazal kanül ile CPAP/non-invaziv pozitif basınçlı ventilasyonu doğrudan karşılaştırmalıdır.

Anahtar Kelimeler: Non-invaziv ventilasyon (NIV), bibliyometrik, solunum yetmezliği, çocuk yoğun bakım, çocuklar

Introduction

Non-invasive ventilation (NIV) is a form of respiratory support provided without direct tracheal intubation. This avoids some complications inherent in invasive ventilation, such as the need for sedation with associated hemodynamic instability, delirium, and nosocomial infections.¹ NIV is primarily indicated for patients with mild-to-moderate acute respiratory failure and has been shown to be more effective than conventional oxygen therapy in selected patient populations.²

Research related to NIV in children has seen significant advancements in recent decades. The purpose of this study is to analyze publication patterns and collaboration among researchers and institutions, and to identify research trends and directions at NIV from 2013 to 2023. Performing a bibliometric analysis is expected to provide a comprehensive understanding of NIV research, enabling healthcare policymakers to make more informed and effective decisions.

Materials and Methods

Scopus searches were conducted on July 23, 2024, to collect basic publication and citation data from article titles, abstracts, and keywords. Scopus search query as executed, including the complete TITLE-ABS-KEY syntax, publication year limits, language restrictions, and keyword filters applied. The search terms used were (non-invasive AND mechanical AND ventilation AND paediatric); the full search string was: TITLE-ABS-KEY (non-invasive AND mechanical AND ventilation AND paediatric) AND PUBYEAR >2012 AND PUBYEAR <2024 AND [LIMIT-TO (LANGUAGE, "English")] AND [LIMIT-TO (EXACTKEYWORD, "Non-invasive ventilation")]. The search was limited to English-language publications and to the publication period 2013-2023. A total of 358 articles were exported as CSV files. Scopus' analyze results, VOSviewer 1.6.19, and Biblioshiny were used to visualize and analyze

occurrences of words and phrases in the titles and keywords of all retrieved articles.

The minimum occurrence of the author's keywords is set at 10. The cluster of co-occurring events is represented by various colours, as indicated by the co-occurrence analysis of the authors' keywords. The frame size corresponds to the appearance of the keywords. Its thickness is proportional to the intensity of the event. Yellow keywords appear in later years (2021 or later) compared with blue keywords (2018 or earlier), as shown in the overlay visualization. Density visualization depicts each term's density; greater thickness indicates higher density. We conducted a literature review of the most-cited publications to gain a deeper understanding of NIV in children.

Results

Of 358 documents, 276 (77.1%) were articles and 55 (14.4%) were reviews (Figure 1). The trend in NIV research publications shows significant fluctuations from 2013 to 2018, followed by a marked increase from 2019 to 2023 (Figure 2). Research development prior to 2020 was limited, possibly owing to constrained research funding or alternative research priorities in child health. Meanwhile, the sharp between 2020 and 2021 was most likely attributable to coronavirus disease-2019 (COVID-19), rendering invasive and non-invasive mechanical ventilators a highly relevant research topic, as they were in high demand.

The countries with the highest number of publications are predominantly developed nations with better healthcare infrastructure and greater access to advanced technologies, led by the United States (124 articles), followed by Canada (43) and Spain (39) (Figure 3). Among the 10 countries with the highest number of publications, only one-India- is from Asia. This indicates limited research from Asia and Southeast

Asia, presenting an opportunity for further investigation of NIV in the region. The most productive author on NIV is Emeriaud G., with 17 articles; this is followed by Jouvét P. (12 articles) and Essouri S. (11 articles). Other productive authors include Rotta AT., Shein SL., Abu-Sultaneh S., Kneyber, MCJ., Conti G., Blackwood B., and Fauroux B. (Figure 3). This can be an opportunity for these productive writers and researchers in various countries to collaborate, thereby expanding the scope of research in this field.

The ten most-cited articles are described in Table 1; seven of the ten concern pediatric cases. The most-cited article is “acute respiratory distress syndrome (ARDS)” by Matthay et al.³ with 822 citations. Followed by “non-invasive versus invasive respiratory support in preterm infants at birth: systematic review and meta-analysis” by Schmölzer et al.⁴ with 417 citations, and “paediatric acute respiratory distress syndrome incidence and epidemiology (PARDIE): an international, observational study” by Khemani et al.⁵ with 248 citations.

Co-occurrence Cluster

Co-occurrence network analysis of author keywords identified four thematic groups, comprising a total of 28 keywords (Figure 4). The densest keyword was NIV. The four research clusters were respiratory insufficiency, mechanical ventilation, continuous positive airway pressure (CPAP), and

ARDS. The overlay visualization showed increasing interest in “extubation failure, CPAP, COVID-19, and mortality” (Figure 4A). The overlay visualization highlights emerging themes such as COVID-19 and mortality, as illustrated in Figure 4B. Most research on NIV using density visualization focuses on NIV, mechanical ventilation, children, pediatrics, COVID-19, and bronchiolitis (Figure 4C). This can be indicated by the bright yellow color. On the other hand, research on NIV is still limited in areas such as weaning, extubation, respiratory insufficiency, pediatric critical care, ARDS, and extubation failure, among others. Thus, addressing these items (Figure 4C) opens opportunities for further research.

NIV in the paediatric population has a wide spectrum of applications, from the prevention and early management of respiratory distress in neonates and therapeutic bridging in paediatric ARDS to postoperative support and long-term home ventilation in children with neuromuscular diseases. The synthesis of ten collected journal publications describes the developmental trajectory of evidence and clinical practice from 2013 to 2023, highlighting benefits, limitations, and open research directions (Tables 1-3).³⁻¹²

A new term that emerged in 2022-2023 is “artificial ventilation”. Artificial ventilation, or mechanical ventilation, is a term used for any method that mechanically assists or replaces spontaneous breathing. This includes invasive methods (such as intubation and mechanical ventilation) and non-invasive methods (such as NIV). The primary goal is to ensure adequate gas exchange and oxygenation in patients who cannot breathe effectively on their own.¹³ Artificial ventilation and NIV are used to manage respiratory failure but are indicated in different clinical scenarios. NIV is often preferred for patients with acute or chronic respiratory diseases or those with mild-to-moderate respiratory disorders because it is associated with fewer complications than invasive ventilation. Although artificial ventilation and NIV both aim to support patients with respiratory failure, they differ in their application, patient comfort, and potential complications.^{14,15}

In neonates, particularly premature infants with RDS, recent evidence confirms that NIV, especially CPAP and non-invasive positive pressure ventilation (s)NIPPV, is the recommended initial respiratory support from birth.⁷ The latest European guidelines indicate that (s)NIPPV is the most effective primary therapy, while HFNC can be considered for stable infants, provided that CPAP/NIPPV is available as a backup option in case of failure. Seven meta-analyses comparing early CPAP with intubation in very preterm infants showed reductions in the need for mechanical ventilation and surfactant use, and an improvement in the combined outcome of mortality and bronchopulmonary dysplasia.¹⁰ From a bibliometric perspective, the topic of early CPAP and NIPPV for preterm

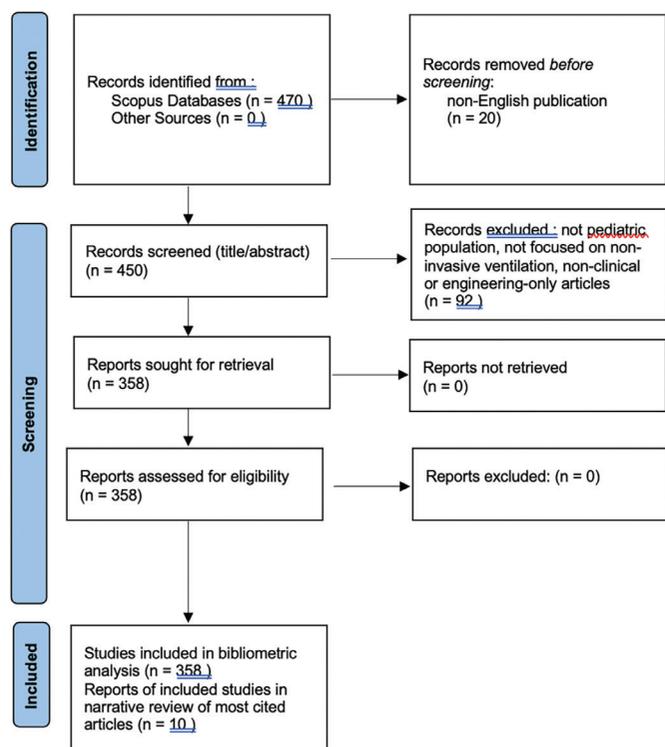


Figure 1. PRISMA-style flow diagram illustrating the identification, screening, and inclusion process for the bibliometric dataset and the narrative review of the most-cited articles

PRISMA: Preferred reporting items for systematic reviews and meta-analyses

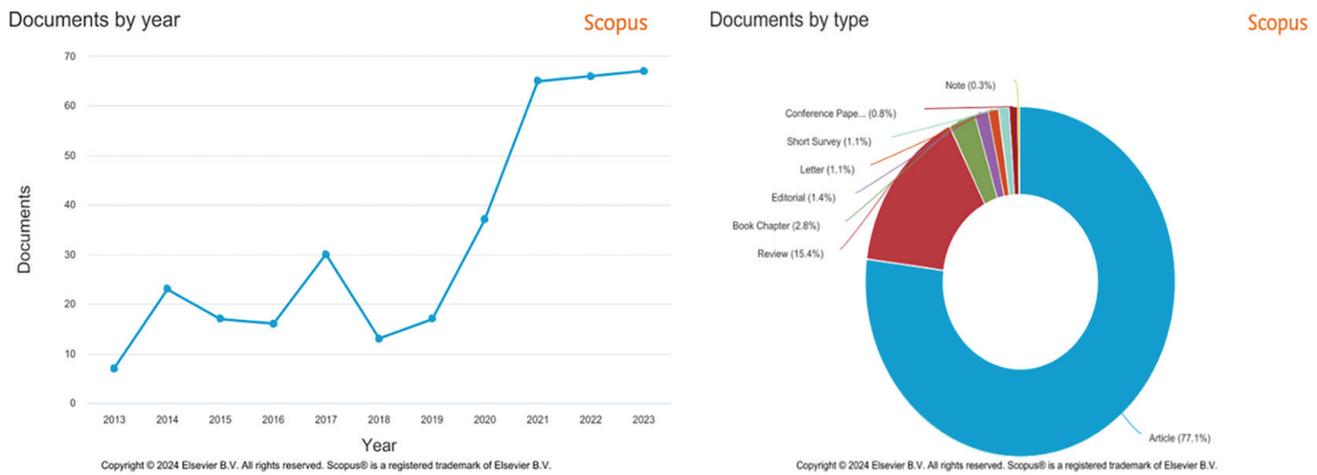


Figure 2. Publication types and publication development

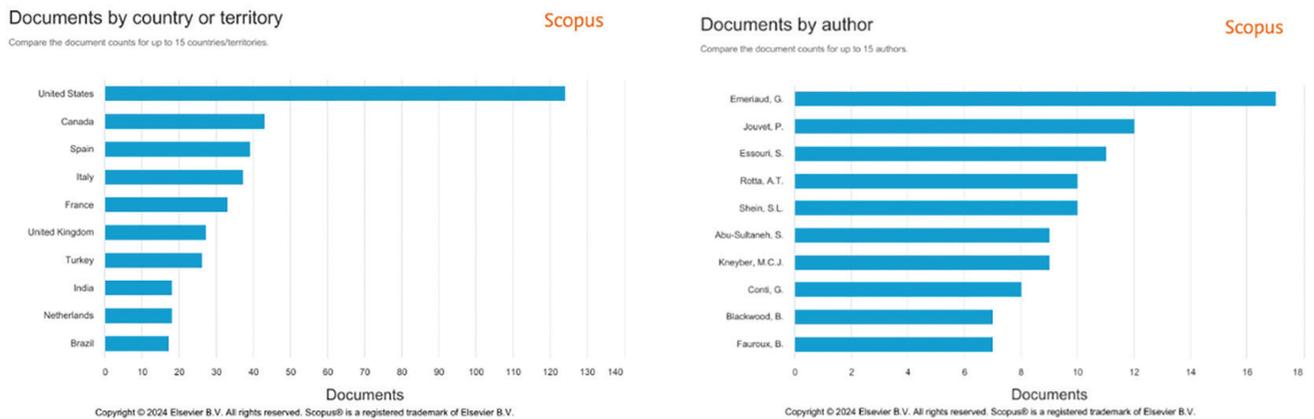


Figure 3. Countries and authors with the most NIV publications
NIV: Non-invasive ventilation,

RDS has become one of the main clusters, exhibiting a high publication rate and supported by strong evidence demonstrating significant clinical benefits, including reduced need for intubation and lower risk of long-term respiratory complications.^{7,10}

In children with PARDS, the international PARDIE cohort study [27 countries; 145 pediatric intensive care unit (PICUs)] confirmed that both diagnosis and severity of PARDS can be determined using the PaO₂/FiO₂ and SpO₂/FiO₂ (PF/SF) ratio, even when the patient has not yet been intubated.^{5,15} Degrees of hypoxemia have been shown to correlate with poor outcomes, and metrics such as ventilator-free days are now consistently used to compare outcomes for both NIV and IMV.¹⁵ In cases of early hypoxemic respiratory failure, evidence in the adult population suggests that high-flow nasal cannula (HFNC) reduces intubation rates and mortality compared with conventional oxygen; this finding has potential implications for pediatric patients with similar conditions.^{3,15}

The key successful NIV in mild-to-moderate PARDS is thorough initial assessment, the selection of the appropriate modality (CPAP/NIPPV versus HFNC), and rigorous monitoring of oxygenation indicators (PF/SF).^{3,15} The paediatric mechanical ventilation consensus conference (PEMVECC) (2017) recommendations suggest considering NIV for patients with obstructive and restrictive diseases, mild-to-moderate PARDS, cardiorespiratory failure, post-cardiac surgery, asthma, and neuromuscular disorders, with strict evaluation within the first hour to assess success.⁷ NIV should not delay intubation if failure criteria are met; selecting an interface that minimizes leakage is crucial.^{12,16} In a cohort of patients undergoing congenital heart surgery, the need for preoperative ventilation, including NIV, was shown to correlate with delayed postoperative extubation. This indicates that NIV is not only a respiratory support tool but also a clinical marker of disease severity relevant to anesthesia planning and ICU management.^{12,16}

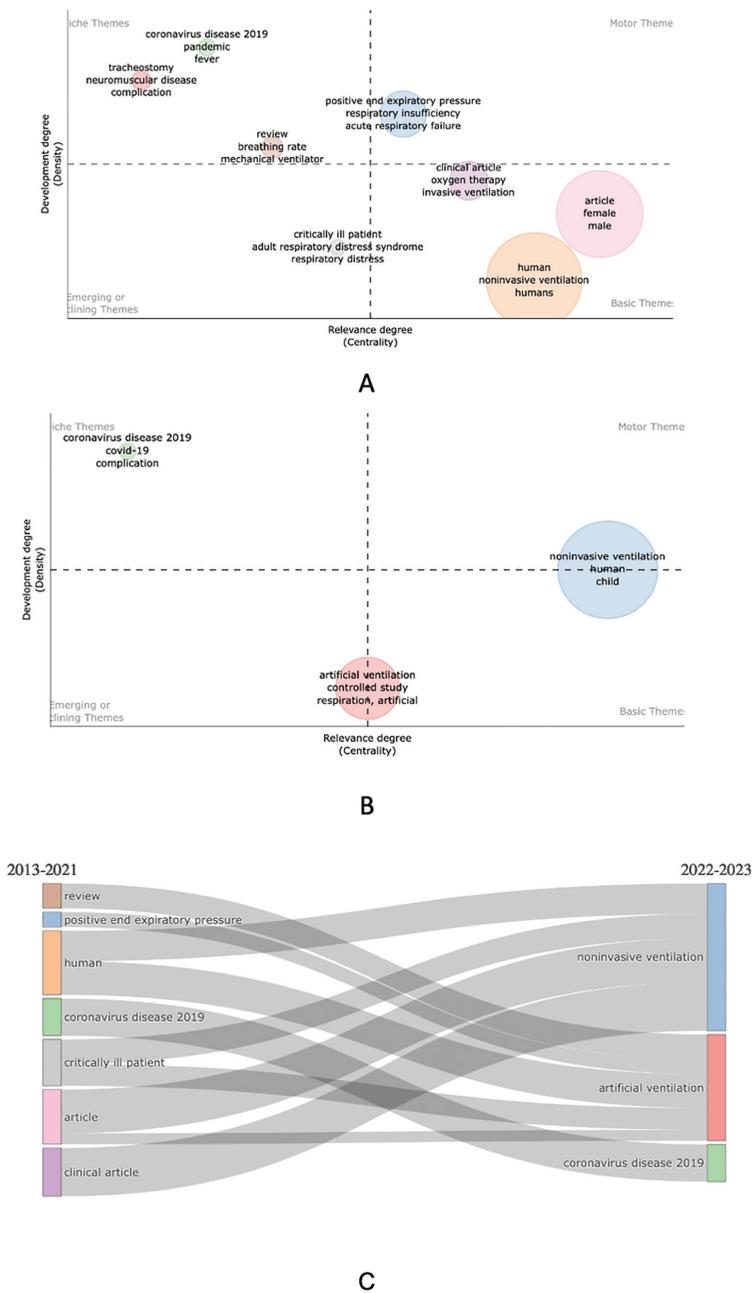


Figure 4. Themes from 2013-2021 (A), themes from 2022-2023 (B), thematic evolution (C)

The long-term use of mechanical ventilation in children continues to increase significantly, as evidenced by Canadian data (1991-2011), which recorded that 83% of patients were using NIPPV, primarily children with neuromuscular diseases, most of whom were treated at home. Studies in Spain during the COVID-19 pandemic also showed a shift toward younger populations, with increased use of NIV and a decrease in the need for invasive ventilation, length of stay, and mortality. Nevertheless, the cases of adolescents with severe multisystem disease confirm the limitations of NIV effectiveness when complex comorbidities are present.^{6,10,17}

Implementing a rapid response system in a tertiary children’s hospital has been shown to reduce the incidence of critical deterioration by 62%, which demonstrates that early detection and rapid intervention play an important role in preventing severe respiratory failure.^{9,18} Overall, evidence from the past decade confirms NIV as an effective strategy for preventing intubation in selected cases, such as neonatal RDS, mild-to-moderate PARDS, obstructive and neuromuscular diseases, provided that an initial assessment is performed, oxygenation indicators (PF/SF) are monitored, and a quick decision is made for intubation if NIV fails.^{5,19}

| No | Title | Year | Source | Citation |
|----|---|------|--|----------|
| 1 | Acute respiratory distress syndrome ³ | 2019 | Nature Reviews Disease Primers | 822 |
| 2 | Non-invasive versus invasive respiratory support in preterm infants at birth: systematic review and meta-analysis ⁴ | 2013 | BMJ (Online) | 417 |
| 3 | Paediatric acute respiratory distress syndrome incidence and epidemiology (PARDIE): an international, observational study ⁵ | 2019 | The Lancet Respiratory Medicine | 248 |
| 4 | First and second waves of coronavirus disease-19: a comparative study in hospitalized patients in Reus, Spain ⁶ | 2021 | PLoS ONE | 205 |
| 5 | Recommendation for mechanical ventilation of critically ill children from the paediatric mechanical ventilation consensus conference (PEMVECC) ⁷ | 2017 | Intensive Care Medicine | 203 |
| 6 | European consensus guidelines on the management of respiratory distress syndrome: 2022 update ⁸ | 2023 | Neonatology | 147 |
| 7 | Impact of rapid response system implementation on critical deterioration events in children ⁹ | 2014 | JAMA Pediatrics | 133 |
| 8 | Pediatric long-term home mechanical ventilation: twenty years of follow-up from one Canadian center ¹⁰ | 2014 | Pediatric Pulmonology | 124 |
| 9 | Severe and fatal forms of COVID-19 in children ¹¹ | 2020 | Archives de Pediatrie | 117 |
| 10 | Should early extubation be the goal for children after congenital cardiac surgery ¹² | 2014 | Journal of Thoracic and Cardiovascular Surgery | 100 |

COVID-19: Coronavirus disease-2019

| Cluster 1 (11 items) | Cluster 2 (7 items) | Cluster 3 (6 items) | Cluster 4 (4 items) |
|-----------------------------|--------------------------|-------------------------------------|--|
| Asthma | Airway extubation | Bronchiolitis | Acute respiratory distress syndrome |
| Child | Extubation | Continuous positive airway pressure | Acute respiratory failure |
| Children | Extubation failure | High-flow nasal cannula | ARDS |
| COVID-19 | Mechanical ventilation | Non-invasive ventilation | Pediatric intensive care |
| Critical care | Pediatric | Pediatric intensive care | |
| Home mechanical ventilation | Respiratory failure | Pediatric intensive care | |
| Intensive care | Weaning | | |
| Mortality | | | |
| Non-invasive ventilation | | | |
| Pediatrics | | | |
| Respiratory insufficiency | | | |

COVID-19: Coronavirus disease-2019, ARDS: Acute respiratory distress syndrome

A bibliometric analysis shows that research on NIV in children is dominated by four clusters: mechanical ventilation, critical care, CPAP/bronchiolitis, and ARDS/extubation failure. The keywords “NIV” and “mechanical ventilation” serve as network hubs, indicating their position as core themes connecting various fields such as neonatology, intensive care, and acute respiratory failure. Between 2013 and 2023, research focus shifted from the application of CPAP/NIPPV in neonates to advanced clinical issues such as weaning, extubation failure, COVID-19, and mortality. There appears to be an increase in the number of new topics after 2019, indicating that the pandemic influenced the expansion of the scope of NIV in children. Overall, this bibliometric analysis indicates that research on NIV is becoming increasingly multidisciplinary,

evolving from technical aspects toward the assessment of clinical outcomes and patient safety, and facilitating cross-sectoral research collaborations, particularly in the fields of pediatric critical care and extubation outcomes.

Conclusion

A comprehensive review of non-invasive mechanical ventilation in children has been conducted. Research on non-invasive mechanical ventilation experienced fluctuations from 2013 to 2018, and then increased from 2019 to 2023. Rapidly growing numbers of publications originate from the United States, Canada, and Spain, while contributions from Southeast Asia remain limited. Future research is expected

Table 3. Summary of the most-cited articles related to non-invasive ventilation

| No | Title | Subject | Methods | Results related to NIV |
|----|---|--|---|--|
| 1 | Acute respiratory distress syndrome | <ul style="list-style-type: none"> ARDS patients, both adults and children, with mild ARDS and non-intubated patients with acute hypoxemic respiratory failure (often early-stage ARDS). The PALICC criteria for pediatric ARDS (PARDS) also include oxygenation parameters for children using NIV. | <ul style="list-style-type: none"> A comprehensive review discussing the epidemiology, pathogenesis, diagnosis, and management of ARDS. | <ul style="list-style-type: none"> NIV may be beneficial for patients with mild ARDS, as it can avoid the risks associated with invasive mechanical ventilation, such as delirium, neuromuscular weakness, and ventilator-associated pneumonia. Although NIV can improve oxygenation, evidence of its benefit for long-term clinical outcomes is still limited, and its effectiveness is highly influenced by the type of interface (e.g., helmet or face mask). Conversely, the use of HFNO has been shown to be safer, better tolerated, and to reduce mortality in acute hypoxemic respiratory failure (early-stage ARDS) through the delivery of low PEEP and a slight increase in carbon dioxide elimination. |
| 2 | Non-invasive versus invasive respiratory support in preterm infants at birth: systematic review and meta-analysis | <ul style="list-style-type: none"> The study subjects were 2,782 very preterm infants (born at a gestational age of less than 32 weeks) drawn from four RCTs that met the inclusion criteria. Of these, 1296 infants were in the nasal CPAP group and 1486 in the intubation group. | <ul style="list-style-type: none"> This study is a systematic review and meta-analysis of RCTs comparing nasal CPAP initiated at birth with intubation in very preterm infants. Searches were conducted in PubMed, Embase, the Cochrane Central Register of Controlled Trials, and Pediatric Academic Society abstracts up to June 2013. | <ul style="list-style-type: none"> A combined analysis showed that the use of nasal CPAP in the delivery room provided significant benefits on the composite outcome of death or BPD at a corrected gestational age of 36 weeks, with one additional infant surviving without BPD per 25 infants treated with CPAP compared with intubation. Separately, there was a significant trend favoring CPAP in reducing the incidence of BPD, although no significant difference in mortality rates was found between the groups. Additionally, the CPAP group showed a significant reduction in the need for mechanical ventilation and surfactant administration. For other secondary outcomes-including pneumothorax, grade III/IV intraventricular hemorrhage, necrotizing enterocolitis, patent ductus arteriosus, and retinopathy of prematurity-there were no significant differences compared with intubation. |
| 3 | Pediatric acute respiratory distress syndrome incidence and epidemiology (PARDIE): an international observational study | <ul style="list-style-type: none"> Children with a new diagnosis of PARDS, whether using IMV or NIV. A total of 744 new cases of PARDS were identified; complete data were available for 708 patients. Regarding NIV, 160 patients were initially diagnosed with PARDS-NIV. | <ul style="list-style-type: none"> Observational study, cross-sectional, international prospective. Conducted in 145 international PICUs (pediatric intensive care units) from 27 countries, during 10 weeks of study between May 2016 and June 2017. | <ul style="list-style-type: none"> The mortality rate in PARDS patients treated with NIV ranges from 10-15%, which is comparable to that in mild-to-moderate PARDS. Approximately half of NIV patients eventually require intubation, with most intubations (86%) occurring within the first 48 hours after diagnosis. Patients who fail NIV and are subsequently intubated have a higher mortality rate (25%), comparable to the mortality rate for moderate-to-severe PARDS with invasive mechanical ventilation. The degree of hypoxemia at diagnosis was found to be strongly associated with an increased risk of intubation and mortality. |
| 4 | First and second waves of coronavirus disease-19: a comparative study in hospitalized patients in Reus, Spain | <ul style="list-style-type: none"> The study involved a total of 468 hospitalized patients with SARS-CoV-2 infection confirmed by RT-PCR. A total of 204 patients were in the first wave and 264 in the second wave. Patients in the second wave tended to be younger, with an increased proportion of children, pregnant women, and postpartum women. | <ul style="list-style-type: none"> A prospective comparative study of COVID-19 patients admitted to Hospital Universitari de Sant Joan (Reus, Spain) between March 15 and October 15, 2020, compared the first and second pandemic waves. Patient inclusion was based on an analytically confirmed SARS-CoV-2 diagnosis and on the requirement for hospitalization. Data analysis was performed retrospectively using medical records. | <ul style="list-style-type: none"> During the second wave of the COVID-19 pandemic, use of non-invasive mechanical ventilation increased, likely influenced by the younger age profile of patients and improved healthcare system preparedness, thereby allowing management of less severe cases with NIV. |

| Table 3. Continued | | | | |
|--------------------|---|--|---|--|
| No | Title | Subject | Methods | Results related to NIV |
| 5 | Recommendations for mechanical ventilation of critically ill children from the Paediatric Mechanical Ventilation Consensus Conference (PEMVECC) | <ul style="list-style-type: none"> Critically ill children: the PEMVECC guidelines apply to critically ill children with various lung conditions (normal, obstructive, restrictive, mixed), chronically ventilated patients, cardiac patients, and pulmonary hypoplasia syndrome, aged less than 18 years. Extremely preterm infants: 2782 extremely preterm infants (gestational age <32 weeks) who received CPAP or intubation. Pediatric PARDS patients: 744 new cases of PARDS, of which 160 patients were initially diagnosed with PARDS and received NIV. Adult COVID-19 patients: 468 adult patients hospitalized with confirmed COVID-19 from two pandemic waves. | <ul style="list-style-type: none"> PEMVECC was initiated by the ESPNIC to develop recommendations on mechanical ventilation in critically ill children. The approach employs the RAND/UCLA appropriateness method, with electronic literature searches conducted in PubMed and EMBASE through September 1, 2015. Eligible studies are those involving individuals under 18 years of age and describing non-invasive or invasive respiratory support, excluding case series, special reports, and publications from the perinatal period. | <ul style="list-style-type: none"> NIV should be considered before intubation in patients with obstructive or restrictive airway disease, mild-to-moderate PARDS, or cardiorespiratory failure, and it is increasingly used for acute respiratory failure, following congenital heart surgery, status asthmaticus, and in neuromuscular disorders. However, intubation should not be delayed if the indication is clear, as there is no definitive evidence on the optimal timing or method of its use. The choice of interface should minimize leakage and should be adapted to local conditions and experience. Although HFNC and CPAP can reduce respiratory work, there is no evidence demonstrating superior outcomes compared with other interventions. Success evaluation should be performed early (approximately 1 hour after initiation) by monitoring vital parameters, the SpO₂/FiO₂ ratio, pH, level of consciousness, and organ function. Evidence for routine NIV use post-extubation is still limited, but in neuromuscular patients, early application of NIV combined with cough assistance techniques can be considered to prevent extubation failure. |
| 6 | European Consensus Guidelines on the management of respiratory distress syndrome: 2022 update | <ul style="list-style-type: none"> The research focus and recommendations concern premature infants, specifically the management of RDS in those with gestational ages over 24 weeks. The recommendations also apply to all infants at risk of RDS, such as those with a gestational age less than 30 weeks who do not require intubation for stabilization. | <ul style="list-style-type: none"> This guideline is the sixth version of the "European Guidelines for the Management of RDS". This document was compiled by a panel of European neonatologists and perinatal obstetricians based on the literature up to the end of 2022, and the strength of evidence was assessed using the GRADE system. | <ul style="list-style-type: none"> NIV, especially CPAP, is recommended as the initial respiratory support for all infants at risk of RDS, and combining NIV with early surfactant administration via the LISA method is an optimal management strategy. The use of NIV has been shown to reduce the need for mechanical ventilation, the risk of re-ventilation, and mortality and the incidence of BPD, while increasing lung volume and reducing apnea and the work of breathing. CPAP remains the primary choice, supported by strong evidence for more than five decades, while HFNC can be considered an alternative in selected cases if CPAP or NIPPV backup is available. The recommended interfaces are short binasal prongs or a mask, with an initial pressure of 6-8 cm H₂O. Intubation should be performed only when the infant does not respond to positive-pressure ventilation and should not be delayed when indicated. Additionally, routine caffeine administration to infants <32 weeks' gestation is recommended to reduce the need for mechanical ventilation. |
| 7 | Impact of rapid response system implementation on critical deterioration events in children | <ul style="list-style-type: none"> The research subjects consist of 1.810 unplanned transfers of pediatric patients from general wards to the pediatric and neonatal ICUs. | <ul style="list-style-type: none"> This quasi-experimental study uses interrupted time series analysis. This study was conducted at a tertiary children's hospital in the US to evaluate the implementation of the RRS, including the MET and the EWS, which started in February 2010. CD, defined as the need for non-invasive or invasive mechanical ventilation within 12 hours of transfer to the ICU, was the primary outcome. | <ul style="list-style-type: none"> Implementing the RRS has been shown to significantly affect outcomes related to mechanical ventilation. After the implementation of RRS, incidents of critical deterioration decreased by 62%; this reduction included cases requiring non-invasive mechanical ventilation. Additionally, there was an 83% reduction in the use of mechanical ventilation-both invasive and non-invasive-within the first 12 hours after transfer to the ICU. The implementation of RRS was also associated with longer intervals before the administration of vasopressors or the initiation of mechanical ventilation, reflecting improved clinical stabilization prior to the need for further therapy. |

Table 3. Continued

| No | Title | Subject | Methods | Results related to NIV |
|----|---|---|---|--|
| 8 | Pediatric long-term home mechanical ventilation: twenty years of follow-up from one Canadian center | <ul style="list-style-type: none"> The study subjects were 379 children under 18 years of age who received LTMV. A total of 313 children (83%) used NIPPV, and 66 (17%) used invasive ventilation. The average age at the initiation of ventilation is 9.6 years, and 99% of children are treated at home. | <ul style="list-style-type: none"> This study is a retrospective review of medical records conducted at a single center in Canada. The focus is on patients receiving LTMV at home between 1991 and 2011. LTMV is defined as the daily use of IMV or NIPPV for at least 3 months, at home or in a long-term care facility, and excludes use of CPAP alone. | <ul style="list-style-type: none"> The use of long-term NIV in children increased exponentially, driven by a more than fivefold rise in NIPPV initiation during the study's second decade. More than 80% of children in this program use NIV, making it the dominant modality, while the proportion of children receiving invasive ventilation is only 17%-the lowest reported globally. Mortality among NIV users (11.2%) is significantly lower than that with invasive ventilation (30%), confirming its safety. Initiation of NIPPV, especially in children with neuromuscular disorders, has been shown to improve respiratory function and survival. Although NIV reduces individuals' need for intensive care, the growing population of LTMV users still increases the burden on healthcare resources. |
| 9 | Severe and fatal forms of COVID-19 in children | <ul style="list-style-type: none"> Pediatric patients admitted for confirmed or highly suspected COVID-19, aged 1 month to 18 years. | <ul style="list-style-type: none"> Retrospective observational study, single-center. | <ul style="list-style-type: none"> Out of the 27 children analyzed, 10 received non-invasive mechanical ventilation as supportive therapy. One fatal case involved a 17-year-old girl with epilepsy and a history of severe neonatal encephalopathy who received NIV rather than intubation, in accordance with a prior decision to withdraw care because of extremely severe comorbid conditions. |
| 10 | Should early extubation be the goal for children after congenital cardiac surgery? | <ul style="list-style-type: none"> This study involved 613 children who underwent congenital heart surgery between July 2010 and December 2012. | <ul style="list-style-type: none"> Observational retrospective analysis of all patients undergoing congenital heart surgery. | <ul style="list-style-type: none"> Preoperative mechanical ventilation, including non-invasive support, has been shown to be a significant predictor of delayed extubation (>24 hours). Analysis shows that patients requiring ventilation before surgery have approximately 9.4-fold higher odds of delayed extubation than those who do not (OR=9.4, 95% CI: 3.2-28.2; p<0.001). In this study, only five patients received preoperative NIV. |

RDS: Respiratory distress syndrome, ARDS: Acute respiratory distress syndrome, PARDS: Pediatric acute respiratory distress syndrome, PALICC: Pediatric acute lung injury consensus conference, PEEP: Positive end-expiratory pressure, RCT: Randomized controlled trial, NIV: Non-invasive ventilation, CPAP: Continuous positive airway pressure, HFNO: High-flow nasal cannula, BPD: Bronchopulmonary dysplasia, IMV: Invasive mechanical ventilation, COVID-19: Coronavirus disease-2019, SARS-CoV-2: Severe acute respiratory syndrome-coronavirus-2, ESPNIC: European Society for Pediatric and Neonatal Intensive Care, RAND/UCLA: Research and development/University of California, Los Angeles, ICU: Intensive care unit, US: United States, RRS: Rapid response system, MET: Medical emergency team, EWS: Early warning score, CD: Critical deterioration, LTMV: Long-term mechanical ventilation, NIPPV: Non-invasive positive pressure ventilation, OR: Odds ratio, CI: Confidence interval, RT-PCR: Reverse transcription- polymerase chain reaction

to focus on several important topics such as weaning, extubation outcomes, and pediatric critical care. External clinical evaluation and patient safety are also important topics that require further study to strengthen clinical practice and evidence-based policies.

Footnotes

Authorship Contributions

Surgical and Medical Practises: S.M., A.G.M., H.F., S.D.J., Concept: S.M., A.G.M., Design: S.M., A.G.M., Data Collection or Processing: A.G.M., Analysis or Interpretation: S.M., H.F., Literature Search: H.F., S.D.J., Writing: S.M., A.G.M., H.F., S.D.J.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

References

- Popat B, Jones AT. Invasive and non-invasive mechanical ventilation. *Medicine (Abingdon)*. 2016;44:346-50.
- Cammarota G, Simonte R, De Robertis E. Comfort during non-invasive ventilation. *Front Med (Lausanne)*. 2022;9:874250.
- Matthay MA, Zemans RL, Zimmerman GA, Arabi YM, Beitler JR, et al. Acute respiratory distress syndrome. *Nat Rev Dis Primers*. 2019;5:18.
- Schmölzer GM, Kumar M, Pichler G, Aziz K, O'Reilly M, et al. Non-invasive versus invasive respiratory support in preterm infants at birth: systematic review and meta-analysis. *BMJ*. 2013;347:f5980.
- Khemani RG, Smith L, Lopez-Fernandez YM, Kwok J, Morzov R, et al. Paediatric acute respiratory distress syndrome incidence and epidemiology (PARDIE): an international, observational study. *Lancet Respir Med*. 2019;7:115-28.
- Iftimie S, López-Azcona AF, Vallverdú I, Hernández-Flix S, de Febrer G, et al. First and second waves of coronavirus disease-19: a comparative study in hospitalized patients in Reus, Spain. *PLoS One*. 2021;16:e0248029.

7. Kneyber MCJ, de Luca D, Calderini E, Jarreau PH, Javouhey E, et al. Recommendations for mechanical ventilation of critically ill children from the paediatric mechanical ventilation consensus conference (PEMVECC). *Intensive Care Med.* 2017;43:1764-80.
8. Sweet DG, Carnielli VP, Greisen G, Hallman M, Klebermass-Schrehof K, et al. European consensus guidelines on the management of respiratory distress syndrome: 2022 update. *Neonatology.* 2023;120:3-23.
9. Bonafide CP, Localio AR, Roberts KE, Nadkarni VM, Weirich CM, et al. Impact of rapid response system implementation on critical deterioration events in children. *JAMA Pediatr.* 2014;168:25-33.
10. Amin R, Sayal P, Syed F, Chaves A, Moraes TJ, et al. Pediatric long-term home mechanical ventilation: twenty years of follow-up from one Canadian center. *Pediatr Pulmonol.* 2014;49:816-24.
11. Oualha M, Bendavid M, Berteloot L, Corsia A, Lesage F, et al. Severe and fatal forms of COVID-19 in children. *Arch Pediatr.* 2020;27:235-8.
12. Harris KC, Holowachuk S, Pitfield S, Sanatani S, Froese N, et al. Should early extubation be the goal for children after congenital cardiac surgery? *J Thorac Cardiovasc Surg.* 2014;148:2642-7.
13. Pierro M, Villamor-Martinez E, van Westering-Kroon E, Alvarez-Fuente M, Abman SH, et al. Association of the dysfunctional placentation endotype of prematurity with bronchopulmonary dysplasia: a systematic review, meta-analysis and meta-regression. *Thorax.* 2022;77:268-75.
14. Saito K, Nishimura E, Ota E, Namba F, Swa T, et al. Antenatal corticosteroids in specific groups at risk of preterm birth: a systematic review. *BMJ Open.* 2023;13:e065070.
15. Celik NB, Tanyildiz M, Yetimakman F, Kesici S, Bayrakci B. Comparison of high flow oxygen therapy versus non-invasive mechanical ventilation for successful weaning from invasive ventilation in children: an observational study. *Medicine (Baltimore).* 2022;101:e30889.
16. Halimić M, Dinarević SM, Begić Z, Kadić A, Pandur S, et al. Early extubation after congenital heart surgery. *Journal of Health Sciences.* 2014;4:156-61.
17. Amin R, Sayal A, Syed F, Daniels C, Hoffman A, et al. How long does it take to initiate a child on long-term invasive ventilation? Results from a Canadian pediatric home ventilation program. *Can Respir J.* 2015;22:103-8.
18. Roberts KE, Bonafide CP, Paine CW, Paciotti B, Tibbetts KM, et al. Barriers to calling for urgent assistance despite a comprehensive pediatric rapid response system. *Am J Crit Care.* 2014;23:223-9.
19. Wong JJ, Phan HP, Phumeetham S, Ong JSM, Chor YK, et al. Risk stratification in pediatric acute respiratory distress syndrome: a multicenter observational study. *Crit Care Med.* 2017;45:1820-8.