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Central Line-Associated Bloodstream Infections in Pediatric Intensive Care Unit

Çocuk Yoğun Bakım Ünitesinde Kateter İlişkili Kan Dolaşımı Enfeksiyonları

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Abstract

Introduction: The aim of this study was to determine the frequency of central line-associated bloodstream infections, risk factors, their relationship with catheter insertion location, and the effect of central line-associated bloodstream infections on mortality and pediatric intensive care unit (PICU) length of stay.

Methods: This was a prospective, observational and cohort study, carried out between November 2009 and February 2011. During this period, all the patients who had central-line were monitored for central line-associated bloodstream infection.

Results: In the study period, 275 patients were admitted to our PICU. The frequency of invasive device usage was 38.9% (107) for central venous catheter, 38.2% (105) for mechanical ventilation, 53.3% (147) for urinary catheter, and 11.3% (32) for artery line. Central line-associated bloodstream infection was detected in 16 (14.8%) of the patients and 23 central line-associated bloodstream infection attacks were observed. There were 14 central line-associated bloodstream infection attacks in 1.000 central venous catheter usage days. There were 168 patients without central venous catheter and 4 (2.4%) of them had blood stream infection. Thirty-six patients died and the mortality rate was 13%. Five of these patients (13.8%) died due to central line-associated bloodstream infection, 27 (25%) of them had central venous catheter and 9 (6%) of them did not (p=0.001).

Conclusion: In conclusion, central line-associated bloodstream infection is one of the serious healthcare-associated infections, and it is an important cause of morbidity and mortality in PICUs.

Keywords: Nosocomial infection, central line-associated bloodstream infection, pediatric intensive care

Öz

Giriş: Bu çalışmanın amacı, kateter ilişkili kan dolaşımı enfeksiyonlarının sıklığını, risk faktörlerini, kateter yerleştirme yerleri ile olan ilişkisini, ayrıca bu enfeksiyonların mortalite ve çocuk yoğun bakım ünitesi (ÇYBÜ) kalış süresine olan etkisini belirlemektir.

Yöntemler: Kasım 2009 ve Şubat 2011 tarihleri arasında gerçekleştirilen ileriye yönelik ve gözlemsel bir kohort çalışmasıdır. Bu tarihler arasında, ünitemizde santral venöz kateteri olan tüm hastalar çalışmaya alındı.

Bulgular: Bu dönemde, ÇYBÜ'de 275 hasta izlendi. İnvazif cihaz kullanım sıklığı; %38,9 (107) santral venöz kateter, %38,2 (105) mekanik ventilasyon, %53,3 (147) idrar kateteri ve %11,3 (32) arter kateteri idi. Hastaların 16'sında (%14,8) (23 atak) kateter ilişkili kan dolaşımı enfeksiyonu saptandı. Bin santral venöz kateter kullanım gününde 14 enfeksiyon atağı gözlemlendi. Santral venöz kateteri olmayan 168 hastanın ise 4 (%2,4) tanesinde kan dolaşımı enfeksiyonu saptandı. Hastaların 36'sı öldü, mortalite oranı %13 idi. Bu hastalardan 5'i (%13,8) kateter ilişkili kan dolaşımı enfeksiyonu nedeniyle öldü, 27'sinde (%25) santral venöz kateter varken, 9'unda (%6) yoktu (p=0,001).

Sonuç: Kateter ilişkili kan dolaşımı enfeksiyonları, hastane ilişkili enfeksiyonlar içinde en ciddi olanlardan biridir ve ÇYBÜ'deki morbidite ve mortalitenin de önemli bir nedenidir.

Anahtar Kelimeler: Nozokomiyal enfeksiyon, kateter ilişkili kan dolaşımı enfeksiyonu, çocuk yoğun bakım

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Introduction

Healthcare-associated infections (HAIs) are hospital-acquired infections and preventable causes of morbidity and mortality in hospitalized patients. They are also associated with prolonged hospital stay.[1-3] Some of the HAIs are bloodstream infections (BSI) [frequently central line-associated bloodstream infection (CLABSI)], nosocomial pneumonia [frequently ventilator-associated pneumonia (VAP)], urinary tract infections [frequently catheter-associated urinary tract infection (CAUTI)], and surgical site infections. HAIs surveillance plays a substantial role in hospital infection control and quality care. Therefore, surveillance studies are vital to understand how HAIs affect the outcome of patients in pediatric intensive care units (PICUs).[4-7]

Most PICUs care for a heterogeneous population of children of varying age, diagnosis, and underlying illnesses.[7,8] Critically ill children frequently require central lines [central venous catheter (CVC) and artery line). CVCs are used in PICU for various reasons such as inotropes, total parenteral nutrition, renal replacement therapies, plasma exchange, blood sampling, invasive monitoring, etc.[7,9,10]

Despite the many benefits of CVCs in PICU, they carry significant risks such as CLABSI and thrombosis. CLABSI is one of the deadliest types of HAIs, with a mortality rate of 12%-25%.[11-13] Several factors, such as those related to the patients (immunodeficiency, need for extracorporeal life support or renal replacement therapy), CVC use (prolonged catheterization, type of CVC material, and anatomical site of insertion and handling), have been shown to increase the risk of CVC infection.[13]

Here, we report an epidemiologic study about the CLABSIs in our PICU. The aim of this study was to determine the frequency of CLABSI, risk factors, the relationship of CLABSI with catheter insertion locations, and the effect of CLABSIs on mortality and PICU length of stay (LOS).

Materials and Methods

Study Design

This was a prospective and observational study held between November 2009 and February 2011. All patients involved in the study were monitored for the development of CLABSI from the day of PICU admission until 48 hours after PICU discharge. This study was performed at the PICU of the Children's Hospital in Ankara University Faculty of Medicine. Our PICU has 6 beds, and it is a level 3 PICU. There are 2 pediatric intensivists, 2 pediatric critical care medicine fellows, and nurse/patient rate is 1/2 in daytime and 1/3 in nighttime. We follow nearly 250 medical and surgical critically ill children, annually. Approval has been obtained from the Ankara University Ethics Committee.

Data Collection

A study form consisting of patient's demographic data, including age, gender, primary diagnosis, chronic diagnoses, and surgery knowledge, was employed. We calculated Pediatric Logistic Organ Dysfunction (PELOD) score[14] at the admission and Pediatric Risk of Mortality III (PRISM III) score[15] at 24th hour of admission for all patients.

CVC were placed for multiple drug administration, inotropes usage, renal replacement therapies (hemodialysis and continuous venovenous hemodiafiltration), plasma exchange, etc. The location of CVC implantation (PICU or operation room) was recorded. At the time of this study, ultrasound was not employed during the CVC insertion. We have recorded the location of insertion such as vena jugularis interna, femoral vein, and subclavian vein. All CVCs were double-lumen in this study.

CVC days, and CLABSI attacks count in 1000 CVC days and the cause of CVC removal (unnecessary, CLABSI or obstruction) were recorded. Finally, the LOS, mortality and morbidity rate (with and without CVC) were determined. We use an infection preventive bundle for CLABSI in our unit.

Definitions

The Centers for Disease Control and Prevention (CDC) definitions were used to diagnose CLABSI.[5] In our PICU, if the patient with CVC has fever, we concurrently take blood culture samples from all the catheter lumens, and peripheral vein. Samples are taken in equal amounts (1-3 mL). The tips of all removed CVC are taken for culture.

Statistical Analysis

The statistical analysis was performed with SPSS 15.0 (SPSS Inc. Chicago, IL). The differences in proportions between the group categories (patients with/without CVC, patients with/without CLABSI) and CVC insertion locations were compared by chi-square test. Descriptive statistics were summarized in tables as counts and percentages for categorical variables and as mean ± standard deviation. A p value of less than 0.05 was considered statistically significant. Additionally, we calculated the PICU LOS as well as survival to PICU discharge.

Results

The mean age of the patients was 87±87.4 months. One hundred fifty-six (56.7%) of them were girls. The mean PRISM III and PELOD scores were 7.6±9.9 and 9.7±13.2, respectively. The frequency of invasive device usage was 38.9% (107) for CVC, 38.2% (105) for mechanical ventilation, 53.3% (147)

for urinary catheter and 11.3% (32) for artery lines. The insertion places of CVC were the operation room (mostly cardiac surgery) in 47 (43.9%) of the patients, and PICU in 43 (40.2%). Moreover; 17 patients had CVC (mostly Broviac catheter) at the admission to PICU. The locations of the CVC insertion were; internal jugular vein in 45 (48.9%), femoral vein in 43 (46.7%), and subclavian vein in 4 (4.3%) of patients.

The total CVC usage days were 1589 in 107 patients with CVC, and the mean usage day was 14.7±9.7 days. CLABSI was detected in 16 (14.8%) patients (23 attacks). There were 14 CLABSI attacks in 1000 CVC usage days. CLABSI was developed at the 10.2±13.6th day of the CVC insertion. The most frequent microbiological agent of CLABSI was *Acinetobacter baumannii* which was responsible from 6 (25.8%) of 23 infection attacks and the other agents are given on Table 1. There were 168 patients without CVC during the study period and 4 (2.4%) of them had BSI. PICU-LOS in patients with/without CVC is given in Table 2.

Thirty-six patients died and the mortality rate was 13%. Five (13.8%) of them died due to CLABSI. There was no statistical difference between insertion locations of CVC and mortality (p=0.0642). The mortality rate was 25% and 6% in patients with and without CVC, respectively (p=0.001).

Table 1. The microbiological agents of central line-associated blood stream infections

Microbiological agents	Patient number (n)	%
Acinetobacter baumannii	6	25.8
Coagulase-negative *Staphylococci*	5	21.7
ESBL (+) *Klebsiella pneumonia*	5	21.7
VRE	2	8.6
Pseudomonas aeruginosa	2	8.6
Escherichia coli	1	4.3
Stenotrophomonas maltophilia	1	4.3
Candida parapsilosis	1	4.3

ESBL: Extended spectrum β-lactamase, VRE: Vancomycin-resistant enterococci

Table 2. The effect of blood stream infection to pediatric intensive care unit length of stay of patients with/without central venous catheter

Group	Number of the patients	PICU length of stay (day) median (min-max) (mean ± SD)	p*
CVC (+) CLABSI (+)	16	17.5 (1-255) (43.7±63.7)	0.005
CVC (+) CLABSI (-)	91	7 (1-71) (11.1±11.4)	
CVC (-) BSI (+)	4	41 (3-51) (29.7±16.1)	0.001
CVC (-) BSI (-)	164	3 (1-37) (5.1±5.3)	

PICU: Pediatric intensive care unit, CVC: Central venous catheter, CLABSI: Central line-associated blood stream infection, BSI: Blood stream infection, SD: Standard deviation
*p value is significant if less than 0.05

Discussion

There are a few adult studies on nosocomial infections in intensive care units in Turkey[16,17], but there is no study showing CLABSIs in PICU. This study is the first one evaluating the rate, risk factors, and outcomes of CLABSI in PICU patients in Turkey.

Our center is a member of the International Nosocomial Infection Control Consortium (INICC).[18-22] Our hospital's INICC nosocomial infection rate and this rate`s comparison with other INICC and CDC National Healthcare Safety Networks, covering the July 2010 - October 2012 period, are given in Table 3.

The risk of CLABSI increases exponentially day by day, especially after the first week of CVC placement.[23] This emphasizes the importance of promptly removing unnecessary CVCs, particularly during the second week of catheterization and thereafter.[13,20,23] Niedner et al.[13] reported that CLABSI incidence was 3.1/1000 central line-days in the PICUs in the USA between October 2006 and December 2007. They found that 99% of patients with CLABSI were infection-free through day 7, but they demonstrated the daily risk of CLABSI doubled to 0.27% per day. Srinivasan et al.[3] reported the data of CDC about CLABSI in all ICUs in the USA in 2001, 2008 and 2009. They reported that the CLABSI rate was 3.6 in 2001 and 1.65 in 2009 per 1.000 central-line days. Jackson et al.[24] analyzed 85.849 ICU patients and they detected CLABSI in 162 (0.2%) of them. In our study, CLABSI developed especially after 7th day of CVC insertion. It might be suggested that CVC may be changed in 7-10 day intervals, with the need for further studies.

Table 3. Our device-associated infections between July 2010 and October 2012, and the comparison of this rate and p values with International Nosocomial Infection Control Consortium and Centers for Disease Control and Prevention National Healthcare Safety Network

DAI type	Our Infection rate*	INICC (2004-2009)[23]	Our PICU vs INICC RR (CI 95%) p	CDC NHSN[3]	Our PICU vs CDC NHSN RR (CI 95%) p
CLABSI	13.3	10.7	1.25 (0.77-2.02) 0.360	3	4.51 (2.79-7.29) 0.001
VAP	4.69	4.72	0.99 (0.37-2.68) 0.990	4.25	1.1 (0.41-2.96) 0.844
ITU	6.46	6.46	1.59 (0.92-2.75) 0.095	1.84	5.58 (3.2-9.71) 0.001

DAI: Device-associated infection, CLABSI: Central line-associated bloodstream infection, VAP: ventilator associated pneumonia, CDC: Centers for Disease Control and Prevention, INICC: International Nosocomial Infection Control Consortium, NSHN: National Healthcare Safety Network, CI: Confidence interval
*Infection attacks per 1000 device days

Cole et al.[25] reported the prevalence of CLABSI in children whose stem cells were transplanted. They had found 5.3/1.000 central-line days and *Staphylococcus epidermidis* was the most commonly identified organism. In our study, *Acinetobacter baumanni* was the most frequent agent of CLABSI, and *Staphylococcus epidermidis* was the second one. Recently, multidrug resistant bacteria have been found to be the most common agent for all HAIs forms such as CLABSI, VAP and CAUTI throughout the world.[26-28]

Some developing countries still have high HAIs rate. The INICC recently reported that the pooled rate of CLABSI, 4.1 per 1.000 central line-days, was nearly 5-fold higher than the 0.8 per 1.000 central line-days reported from comparable US ICUs.[29] Dueñas et al.[19] in their prospective cohort, active surveillance study in a PICU in El Salvador between January 2007 and November 2009 found that CLABSI incidence was 9.9/1.000 catheter-line days. Our data is comparable with Dueñas et al.[19] data. It can be related with the insufficient places, nurse count, economic sources, and education in our countries.

Some clinicians think that femoral location of CVC has higher risk for CLABSI than the other sites.[13,22,26] Krishnaiah et al.[27] investigated the effect of the location of catheter insertion as external and internal CVC insertion. They determined that the rate of CLABSI was 23.1 and 9.7/1.000 catheter-days in patients with external and internal CVC, respectively. In our study, we have frequently used internal jugular and femoral vein as insertion site of CVC. There was not a significant difference between insertion sites and CLABSI rate. Additionally, we did not find a statistically significant difference between insertion places (PICU, operation room) and CLABSI rate. Besides that, the hospital acquired infection preventive bundles such as hand hygiene, insertion area sterilization, mask use, and sterile gown should be applied, even if the insertion place is PICU.[27]

Conclusion

In conclusion, CLABSI is a very important infection as an HAI. It can cause prolonged PICU stay as well as morbidity and mortality. Infection control committees must regularly inspect centers providing healthcare for critically ill children. Moreover, such centers must always try to improve their healthcare quality assuring hand hygiene adherence and isolation rules, and providing appropriate nurse to patient ratio, distance between patient beds, etc. Finally, PICU staff must apply the appropriate nosocomial infection preventive strategies.

Ethics

Ethics Committee Approval: Approval has been obtained from the Ankara University Ethics Committee.

Informed Consent: Approval was obtained from the family of the patients.

Peer-review: Internally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: T.K., A.Y., Ç.Ö., H.Ö., A.K., B.A., H.G., C.A., G.Ö., D.A., E.Ç., E.İ., Concept: T.K., A.Y., Ç.Ö., H.Ö., A.K., B.A., H.G., C.A., G.Ö., D.A., E.Ç., E.İ., Design: T.K., A.Y., Ç.Ö., H.Ö., A.K., B.A., H.G., C.A., G.Ö., D.A., E.Ç., E.İ., Data Collection or Processing: T.K., A.Y., Ç.Ö., H.Ö., A.K., B.A., H.G., C.A., G.Ö., D.A., E.Ç., E.İ., Analysis or Interpretation: T.K., A.Y., Ç.Ö., H.Ö., A.K., B.A., H.G., C.A., G.Ö., D.A., E.Ç., E.İ., Literature Search: T.K., A.Y., Ç.Ö., H.Ö., A.K., B.A., H.G., C.A., G.Ö., D.A., E.Ç., E.İ., Writing: T.K., A.Y., Ç.Ö., H.Ö., A.K., B.A., H.G., C.A., G.Ö., D.A., E.Ç., E.İ.

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