Central Venous Catheterization Related Complications in Pediatric Intensive Care Unit at Queen Sirikit National Institute of Child Health

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Background: *Central venous catheterization (CVC) is an indispensable route of venous access in management of critically ill patients. Potential CVC related complications include mechanical and infectious complications.*
Objective: *To determine type, incidence and risk factor of CVC related complications in pediatric patients.*
Material and Method: *Prospective observational study of all patients who underwent CVC in pediatric intensive care unit (PICU) at Queen Sirikit National Institute of Child Health, over a 1-year period.*
Results: *The study included 137 patients, of whom 63.5% were males. The mean age was 36.7±4.4 months. There were 204 CVC attempts with total indwell time of 2,002 days. The rate of mechanical complication was 19%, including failure to place catheter (9.3%), hematoma (4.9%), arterial puncture (2%) and pneumothorax (1.5%). Patient body mass index (BMI) >30 kg/m^2, internal jugular venous catheterization, and longer insertion time (>30 minutes) were associated with high mechanical complication rates. The incidence density of catheter related blood stream infection (CRBSI) was 7.5/1,000 catheter-days. Femoral vein placement had significant higher incidence of CRBSI.*
Conclusion: *CVC related complications are comparable to previous studies. Risk factors of mechanical complications include high BMI, internal jugular venous catheterization and longer insertion time. Femoral venous catheterization is the only risk factor for CRBSI.*

Keywords: *Central venous catheterization, Mechanical complication, Catheter related blood stream infection*

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Central venous catheterization (CVC) is essential for the management of critically ill patients. It is placed in a large central vein, usually superior vena cava. CVC provides necessary vascular access for administration of medications, fluids, parenteral nutrition, blood products, blood collection, hemodialysis and hemodynamic monitoring[1,2]. Despite its utility, CVC is often associated with mechanical and/or infectious complications, especially in infants and children[1-4]. Mechanical complications include placement failure, catheter malposition, hematoma, arterial puncture, pneumothorax, thromboembolism, dysrhythmia and death. Infectious complications include local site infection, catheter related bloodstream infection (CRBSI), septic thrombophlebitis, endocarditis, and other metastatic infections. Previous studies reported mechanical complication rates of 5-34% and CRBSI rates varying from 0.2 to 11 episodes per 1,000 catheter-days[1-3].

The aims of this study were to determine the incidence, type and risk factor of CVC related complications in pediatric patients.

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Material and Method

The present study was conducted in the pediatric intensive care unit (PICU) at Queen Sirikit National Institute of Child Health, over a 1-year period starting from March 1, 2010. All pediatric patients, aged 1 month to 18 years, who had CVC were enrolled. The present study was approved by the Institutional Ethical Review Board. The Pediatric Multi-Lumen Polyurethane Central Venous Catheters (Arrow® International, Teleflex Inc) were used in this study.

Data included patient demographics, operator characteristics, procedure characteristics and complication type. Patient demographics were age, sex,

body mass index (BMI), and total indwell time. Operator characteristics were healthcare personnel who performed CVC (attending staff, pulmonary fellow or pediatric resident). Procedure characteristics were emergency or non-emergency condition, placement site, and insertion time. Mechanical complications were characterized as placement failure, catheter malposition, hematoma, arterial puncture, pneumothorax, hemothorax, air embolism, dysrhythmia or death. CRBSI was diagnosed by using CDC/NHSN surveillance definition of health care-associated infection[5,6].

Quantitative parameters were expressed as mean ± standard deviation. Potential risk factors of complication were analyzed by Chi-square test. Characteristics associated with $p<0.1$ were entered into a multivariate logistic regression analysis. The p-value <0.05 was considered statistically significant. All computations were performed by SPSS Statistics version 16.0 (SPSS, Chicago, IL).

Results

137 patients were enrolled, of 204 CVC attempts. Sixty-three percent were male, with male to female ratio of 1.74:1. The mean age was 36.7±4.4 months (range 1-225 months). The total indwell time was 2,002 days. Patient characteristics are shown in Table 1.

Most of CVC (89%) were performed by pediatric residents and pulmonary fellows, and under non-emergency condition (79%). CVCs were placed at the femoral vein, internal jugular vein and subclavian vein at frequency of 63.2, 32.8 and 3.9%, respectively. Most of CVC (92.2%) were inserted within 30 minutes (Table 2).

There were 39 (19.1%) mechanical complications, of which the majority was placement failure (9.3%). Pneumothorax, a serious complication, occurred in 1.5% of all attempts (Table 3). Patients with BMI >30 kg/m^2 had significantly higher complication rate (57%) than BMI 10-20 (18%) and BMI 20-30 (15%) kg/m^2 ($p = 0.032$). There was no significant difference in complication rates between staff, pulmonary fellow and pediatric resident (Table 4). Complications of CVC under emergency and non-emergency conditions were not statistically significant ($p = 0.16$). The CVC site and insertion time significantly correlated with mechanical complications. Subclavian, internal jugular, and femoral veins were associated with mechanical complications in 25, 28.3, and 14%, respectively ($p = 0.047$). The complication rates were 10.5, 18.7 and 62.5% at the insertion time of <15, 15-30 and >30 minutes, respectively ($p = 0.004$). The BMI >30 kg/m^2 (odds ratio (OR) 7.111, 95% confidence interval (CI) 1.299-38.931), internal jugular venous catheterization (OR 2.405, 95% CI 1.064-5.437), and insertion time >30 minutes (OR 10.145, 95% CI 3.129-32.899) all remained significant risk factors for mechanical complications by multivariate analysis (Table 5).

CRBSI occurred in 7.3% of all attempts, with the incidence density of 7.5 per 1,000 catheter-days (Table 6). The BMI of the patients ($p = 0.10$), operator characteristics ($p = 0.74$), emergency insertion condition (p 0.392) and insertion time ($p = 0.39$) did not correlate with CRBSI. There was significant difference in CRBSI between CVC sites, with the highest incidence at femoral vein ($p = 0.042$).

Table 1. Patient characteristics (n = 137)

Characteristics	Mean ± SD
Age (months)	36.7±4.4
Male, n (%)	87 (63.5)
BMI (kg/m^2)	15.5±0.6
Indwell time (days)	9.8±1.4

BMI = body mass index

Table 2. Characteristics of CVC attempts (n = 204)

Characteristics	n (%)
Operator	
Attending staff	23 (11.0)
Pulmonary fellow	83 (41.0)
Pediatric resident	98 (48.0)
Emergency condition	43 (21.0)
Catheter site	
Femoral vein	129 (63.2)
Internal jugular vein	67 (32.8)
Subclavian vein	8 (3.9)
Insertion time (minutes)	
<15	76 (37.3)
15-30	112 (54.9)
>30	16 (7.8)

Discussion

The present study described the complications associated with the central venous catheterization in a multidisciplinary PICU in a tertiary care hospital over a 1-year period. Most of our patients were young children (mean age 36.7 months). Eighty-nine percent of procedures were performed by pediatric residents and pulmonary fellows and 11% by attending

Table 3. Mechanical complications by CVC site (n = 204)

Complications	n (%)				
	All catheters (n = 204)	Subclavian (n = 8)	Internal jugular (n = 67)	Femoral (n = 129)	*p*-value
Placement failure	19 (9.3)	1 (12.5)	6 (8.9)	12 (9.3)	0.936
Hematoma	10 (4.9)	0 (0)	5 (7.5)	5 (3.9)	0.064
Arterial puncture	4 (2.0)	0 (0)	3 (4.5)	1 (0.7)	0.191
Pneumothorax	3 (1.5)	0 (0)	3 (4.5)	N/A	0.656
Malposition	3 (1.5)	1 (12.5)	2 (2.9)	0 (0)	0.008
Total	39 (19.1)	2 (25.0)	19 (28.3)	18 (14.0)	0.047

Table 4. Mechanical complications and operator (n = 204)

Complications	n (%)			
	Staff (n = 23)	Pulmonary fellow (n = 83)	Pediatric resident (n = 98)	*p*-value
Placement failure	2 (8.7)	6 (7.2)	12 (12.2)	0.518
Other complications	4 (17.4)	8 (9.6)	7 (7.1)	0.304
Total	6 (26)	14 (16.9)	19 (19.4)	0.607

Table 5. Multivariate analysis of risk factors

Variables	Adjusted OR	95% CI	
		Lower	Upper
Internal jugular vein	2.405	1.064	5.437
Staff	0.486	0.062	3.824
Insertion time >30 minutes	10.145	3.129	32.899
BMI >30 (kg/m^2)	7.111	1.299	38.931
Male gender	0.555	0.247	1.246
Emergency	0.983	0.374	2.582

OR = odds ratio; CI = confidence interval

Table 6. Catheter related blood stream infection (CRBSI) by CVC sites (n = 204)

CRBSI	All catheters (n = 204)	Subclavian (n = 8)	Internal jugular (n = 67)	Femoral (n = 129)	*p*-value
Total indwell time (days)	2002	68	604	1330	
CRBSI, n (%)	15 (7.3)	0 (0)	1 (1.5)	14 (10.8)	0.042
CRBSI density (per 1,000 catheter-days)	7.5	0	1.6	10.5	

staffs. We found no significant differences in complication rates between the operators, although there was a trend toward a higher complication rate in staff group. Attending staff usually perform CVC

insertion in the most complicated patients. A prospective study by Sznajder JI et al showed that overall failure and complication rates of CVC were significantly higher in inexperienced physicians[7]. The most frequent insertion site (63.2%) in the present study was femoral vein (63.2%). In general, femoral venous catheterization is preferred in small children since it is a relatively safe and simpler procedure, especially for in-training operators such as pediatric residents[2,8,9].

The overall rate of mechanical complications (19%) is comparable to previous studies (3.4-34%)[1,2,7,9-11]. Placement failure was the most common mechanical complication, occurring at 9.3% of all attempts. After exclusion of placement failure, the other mechanical complications occurred in only 9.8%, with hematoma occurring in the majority. Eisen LA et al described 33% mechanical complication rate in adult patients: placement failure (22%), arterial puncture (4.7%), incorrect position (3.6%), pneumothorax (1.3%), subcutaneous hematoma (0.8%), hemothorax (0.3%), and death (0.3%)[1]. Bagwell EC et al reported 33 life-threatening complications and 11 deaths (33% mortality rate) in 40 pediatric surgical patients who had acute complications from CVC[9]. Pneumothorax, the most serious complication in the present study, was found in internal jugular venous catheterization. This was probably explained by few patients (3.9%) who underwent subclavian vein placement. Subclavian is generally more likely than internal jugular venous catheterization to be complicated with pneumothorax and hemothorax, whereas internal jugular venous catheterization is more likely associated with arterial puncture[1,2,9-11]. Hematoma and arterial puncture occurred more frequently at internal jugular than femoral venous catheterization in the present study.

Three factors were found to be significantly associated with mechanical complications: BMI >30 kg/m^2, internal jugular vein placement, and insertion time >30 minutes. BMI >30 kg/m^2 was associated with increased complication rate (OR 7.111, 95% CI 1.299-38.931). Obesity significantly increases the difficulty of patient management, including equipment inadequacy, vital sign measurement, chest auscultation, venipuncture, cannulation, drug dosing, technical difficulties in ambulance transportation[12]. Management difficulty generally increased substantially when the BMI was within the obese (BMI 30.0-39.9 kg/m^2) or morbidly obese (BMI >40.0 kg/m^2) range[12].

In the present study, internal jugular venous catheterization was associated with higher mechanical complication rates (OR 2.405, 95% CI 1.064-5.437). This was comparable to study of Steele R et al who reviewed mechanical complication rate of CVC in emergency department over a 3-year period. The study showed a 3.4% complication rate with the highest rate (5.2%) at the internal jugular vein[11]. Nevertheless, there are many conflicting results. Eisen LA et al reported highest complication rate at the subclavian vein (39%), attributable to the high rate of failure to place[1]. Merrer J et al conducted a randomized controlled clinical trial study at 8 ICU's in France to compare the complications between femoral and subclavian venous catheterization. They found comparable rates of overall mechanical complications between both groups[10]. Risk factors for mechanical complication were long duration of insertion and insertion during the night. McGee DC et al reported overall similar risks of mechanical complications between internal jugular and subclavian venous catheterization[2].

For infectious complication, CRBSI rate (7.3% or 7.5 per 1,000 catheter-days) was comparable to previous studies (1-26%). The rate of central catheter associated infections in PICU (7.3 per 1,000 catheter days) was more than double that reported in adult medical ICU[4]. A randomized trial found that subclavian venous catheterization was associated with a significantly lower rates of total infectious complications[10]. Goetz AM reported an association between catheter contamination and femoral venous catheterization[13]. In present study, the only risk factor associated with CRBSI was femoral venous catheterization.

Conclusion

Mechanical and infectious complication rates of central venous catheterization in critically ill children are comparable to previous studies. Most of mechanical complications were failure to place catheter and non-serious complications. Risk factors associated with mechanical complication included high BMI (>30 kg/m^2), internal jugular venous catheterization, and long insertion time. Femoral venous catheterization was the only risk factor for CRBSI.

Potential conflicts of interest

None.

References

1. Eisen LA, Narasimhan M, Berger JS, Mayo PH, Rosen MJ, Schneider RF. Mechanical complications of central venous catheters. J Intensive

Care Med 2006; 21: 40-6.
2. McGee DC, Gould MK. Preventing complications of central venous catheterization. N Engl J Med 2003; 348: 1123-33.
3. Wolf J, Curtis N, Worth LJ, Flynn PM. Central line-associated bloodstream infection in children: an update on treatment. Pediatr Infect Dis J 2013; 32: 905-10.
4. Randolph AG, Brun-Buisson C, Goldmann D. Identification of central venous catheter-related infections in infants and children. Pediatr Crit Care Med 2005; 6 (3 Suppl): S19-24.
5. Horan TC, Andrus M, Dudeck MA. CDC/NHSN surveillance definition of health care-associated infection and criteria for specific types of infections in the acute care setting. Am J Infect Control 2008; 36: 309-32.
6. O'Grady NP, Alexander M, Burns LA, Dellinger EP, Garland J, Heard SO, et al. Guidelines for the prevention of intravascular catheter-related infections. Clin Infect Dis 2011; 52: e162-93.
7. Sznajder JI, Zveibil FR, Bitterman H, Weiner P, Bursztein S. Central vein catheterization. Failure and complication rates by three percutaneous approaches. Arch Intern Med 1986; 146: 259-61.
8. Abad CL, Safdar N. Catheter-related bloodstream infections. IDSE: Infectious Disease Special Edition 2011; 9: 84-98.
9. Bagwell CE, Salzberg AM, Sonnino RE, Haynes JH. Potentially lethal complications of central venous catheter placement. J Pediatr Surg 2000; 35: 709-13.
10. Merrer J, De Jonghe B, Golliot F, Lefrant JY, Raffy B, Barre E, et al. Complications of femoral and subclavian venous catheterization in critically ill patients: a randomized controlled trial. JAMA 2001; 286: 700-7.
11. Steele R, Irvin CB. Central line mechanical complication rate in emergency medicine patients. Acad Emerg Med 2001; 8: 204-7.
12. Kam J, Taylor DM. Obesity significantly increases the difficulty of patient management in the emergency department. Emerg Med Australas 2010; 22: 316-23.
13. Goetz AM, Wagener MM, Miller JM, Muder RR. Risk of infection due to central venous catheters: effect of site of placement and catheter type. Infect Control Hosp Epidemiol 1998; 19: 842-5.

ภาวะแทรกซ้อนจากการใส่สายสวนหลอดเลือดดำส่วนกลางในหอผู้ป่วยเด็กวิกฤตสถาบันสุขภาพเด็กแห่งชาติมหาราชินี

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ภูมิหลัง: การใส่สายสวนหลอดเลือดดำส่วนกลาง มีความสำคัญและจำเป็นในการดูแลรักษาผู้ป่วยในภาวะวิกฤต แต่อาจเกิดภาวะแทรกซ้อน ได้แก่ ภาวะแทรกซ้อนชนิด mechanical และการติดเชื้อในกระแสเลือดสัมพันธ์กับสายสวน (catheter related blood stream infection (CRBSI))

วัตถุประสงค์: เพื่อศึกษาชนิดของภาวะแทรกซ้อน, อัตราการเกิดภาวะแทรกซ้อนและปัจจัยที่สัมพันธ์กับการเกิดภาวะแทรกซ้อนจากการใส่สายสวนหลอดเลือดดำส่วนกลาง

วัสดุและวิธีการ: เป็นการศึกษาวิจัยเชิงสังเกตุ ของผู้ป่วยในหอผู้ป่วยเด็กวิกฤต สถาบันสุขภาพเด็กแห่งชาติมหาราชินี เป็นเวลา 1 ปี

ผลการศึกษา: มีผู้ป่วยเข้าร่วมการศึกษา 137 ราย เพศชายร้อยละ 63.5 อายุเฉลี่ย 36.7±4.4 เดือน ได้รับการใส่สายทั้งหมด 204 ครั้ง ระยะเวลาที่ใส่รวมทั้งหมด 2,002 วัน พบภาวะแทรกซ้อนชนิด mechanical ร้อยละ 19 ได้แก่ failure to place (ร้อยละ 9.3), hematoma (ร้อยละ 4.9), arterial puncture (ร้อยละ 2) และ pneumothorax (ร้อยละ 1.5) พบว่าผู้ป่วยที่มี BMI >30 kg/m^2, การใส่สายที่บริเวณ internal jugular vein และระยะเวลาในการใส่ที่นานกว่า 30 นาที มีอัตราการเกิดภาวะแทรกซ้อนชนิด mechanical สูงสุดพบอุบัติการณ์ของ CRBSI เท่ากับ 7.5/1,000 catheter-days โดยการใส่สายที่ตำแหน่ง femoral vein มีอัตราการเกิด CRBSI สูงสุด

สรุป: ภาวะแทรกซ้อนจากการใส่สายสวนหลอดเลือดดำส่วนกลางพบอุบัติการณ์ใกล้เคียงกับการศึกษาในอดีต โดยมีปัจจัยเสี่ยงของการเกิดภาวะแทรกซ้อนชนิด mechanical คือ BMI >30 kg/m^2, การใส่สายที่ internal jugular vein และระยะเวลาในการใส่ที่นานกว่า 30 นาที ขณะที่ปัจจัยเสี่ยงของ CRBSI คือ การใส่สายบริเวณ femoral vein