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The evaluation of central venous catheterization complications in a pediatric intensive care unit

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Summary

Aim: Central venous catheter insertion is a method commonly used in intensive care units. In this study, we aimed to evaluate central venous catheters inserted in the pediatric intensive care unit and the risk factors associated with complications of central venous catheters.

Material and Method: Between 01.07.2007-01.08.2009, in İzmir Training and Research Hospital, Clinics of Pediatrics, Pediatric Medical-Surgical Intensive Care Unit, 110 patients with central venous catheters (mean age: 46.9±54.5 months, median age: 21 months, range 1 month-228 months: 49 female / 61 male) were studied.

Results: A total of 128 catheters [femoral, subklavian and jugular catheters in 88 (68.8%), 37 (28.9%) and 3 (2.3%), respectively] were inserted in 110 patients. During catheter insertion, six insertion-related complications (4.7%) occured whereas 12 infections (9.4%), six thromboses (4.7%) and two (1.6%) accidental removals were observed during follow-up. No risk factors were observed for catheter insertion-related complications ($p > 0.05$). There was no significant difference in the risk of complications between the cases with subclavian and those with femoral catheterization ($p>0.05$).

Conclusions: The placement of central venous catheters in pediatric intensive care unit is a safe procedure in experienced hands. *(Turk Arch Ped 2011; 46: 207-11)*

Key words: Central venous catheterization, complication, pediatric intensive care unit.

Introduction

Central venous catheter insertion is a widely used method to perform procedures including invasive hemodynamic monitoring, medication and fluid administration, blood sampling, hemodialysis and plasmapheresis. Percutaneous central venous catheter insertion is frequently performed in intensive care units. In pediatric patients, the most commonly preferred regions for CVC insertion include femoral, subclavian and internal jugular veins. Technical problems and complications are more frequently observed especially in pediatric patients. Complications are examined in three groups including mechanical, thrombotic and infectious complications. Experience of the person performing the intervention, the region where the catheter is inserted and various risk factors are effective in the number and severity of these complications (1,2).

In this study, it was aimed to evaluate the complications observed in our patients in whom CVC was inserted for various reasons in our Pediatric Intensive Care Unit and related risk factors.

Material and Method

The record of 110 patients in whom CVC was inserted for various reasons (invasive hemodynamic monitoring, infusion of medication and fluids, total parenteral nutrition. etc.) and who were hospitalized between the dates of 07.01.2007 and 08.01.2009 in the Medical-Surgical Pediatric Intensive care Unit including nine beds in the Ministry of Health İzmir

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Tepecik Education and Research Hospital Pediatric Clinic were examined retrospectively. In the study, the localization of the insertion of CVC, duration of catheterization and complications were evaluated. For catheter insertion platelet count had to be >50000/mm3 and prothrombin and partial thromboplastin times had to be within normal limits. If these values were not normal, necessary blood products were administered. All subclavian and jugular catheters and in cases where the intervention is considered to be risky femoral catheters were inserted by the responsible specialist of the Pediatric Intensive Care Unit and other femoral catheters were inserted by a senior pediatrics research fellow educated in the Intensive Care Unit under guidance of a specialist using Seldinger technique. In all patients, sedation (0.1 mg/kg intravenous midazolam) and analgesia (1 µg/kg intravenous phentanyl) were performed before the procedure. Neuromuscular blocking agent (0.1 mg/kg intravenous vecuronium) was also used, if necessary. During the intervention, patients were monitored in terms of heart rate and rythm, respiratory rate and oxygen saturation. For catheterization, decision for selecting subclavian, femoral or internal jugular vein was left to the operator. However, subclavian vein was not preferred in patients with hemorrhagic diathesis. 4 Fr double lumen transient catheter (Poliüretan, Braun Melsungen, Melsungen, Germany) was inserted in patients with a body weight of <5 kg. 7 Fr was used for patients with a body weight of 5-10 kg and 7 Fr was used for patients with a body weight of>20 kg. Before the procedure appropriate hand washing and aseptic conditions were provided. Sterilization of the region where the catheter will be inserted was performed using 10% povidon iode. After the procedure direct graphy was obtained and it was confirmed that the tip of the catheter was between vena cava superior and the right atrium for subclavian and jugular catheters and in the vena cava inferior for femoral catheters. All catheter lumens were checked for blood flow daily. Continuous infusion of appropriate fluid was administered for protection from catheter obstruction. Continuous heparinization was not performed in any patient.

Erythema and enduration 2 cm around the exit site of the catheter without bloodstream infection was noted as infection of the catheter exit site. Growth of the same microorganism in blood culture obtained from the catheter and in peripheral blood culture and presence of clinical signs and symptoms of sepsis (fever, hypothermia, leucocytosis, tachycardia, metabolic acidosis etc.) was defined as catheter related bloodstream infection (3).

Mortality risks in all subjects were predicted using PIM II (Pediatric Index of Mortality) (http://www.sfar.org/scores2/pim22.php) and PRISM (Pediatric Rsik of Mortality) (http://www.sfar.org/scores2/prism2.php) models.

SPSS 13.0 package program was used for statistical analysis. Numeric data were given as mean±standard deviation, median and ranges (the lowest-the highest). Categorical data were given as percent (%). Numeric values with a normal distribution were evaluated using Student-t test and numeric values which did not show a normal distribution were evaluated using Mann-Whitney U test. Categorical data were evaluated using qui-square test. A p values of <0.05 was considered to be statistically significant.

Results

In this study, CVC was inserted in a total of 110 patients 49 of whom were female (44.5%) and 61 of whom were male (55.5%) (one catheter in 93 patients, 2 catheters in 16 patients and 3 catheters in one patient). Mean age of the patients was 46.9±54.5 months (median age 21 months; the youngest one month-the oldest 228 months). Mean time of hospitalization was 25.4±32.3 days (median 14 days; the shortest one day-the longest 160 days). Values obtained by using mean PIM and PRISM scales of the subjects were calculated to be 34.8±32.7 (median 20.6; the lowest 0.3-the highest 100) and 33.6±32.1 (median 19.2; the lowest 0.7-the highest 100), respectively.

Mean dwell time of the catheter was found to be 10.2±7.5 days (median 8 days; the shortest one day-the longest 33 days). An underlying chronic disease was found in 55 of the subjects (50%) and malnutrition was found in 21 of the subjects (19%). A total of 40 patients (36.4%) died during the period of follow-up. When diagnoses of the subjects at admission to the intensive care unit were evaluated, sepsis (33 subjects), lung disease (30 subjects) and trauma (12 subjects) constituted the largest group (Table 1).

Femoral catheter was inserted in 88 of the subjects (68.8%), subclavian catheter was inserted in 37 of the subjects (28.9%) and jugular catheter was inserted in 3 of the subjects (2.3%). The right side of the body was used most frequently (100 times; 83.3).

88 of the catheters (68.8%) were inserted because of shock to administer appropriate fluids and medical treatment. 40 catheters (31.2%) were inserted to provide

Table 1. Diagnoses of the subjects at admission to the intensive care unit

Diagnosis at admission to the intensive care unit	n	%
Sepsis	33	30.0
Lung disease	30	27.3
Trauma	12	11.0
Neurologic disease	9	8.2
Hemato-oncologic disease	7	6.4
Cardiovascular system disease	5	4.5
Intoxication	4	3.6
Gastrointestinal system disease	3	2.7
Genitourinary system disease	2	1.8
Other	5	4.5
Total	110	100

Table 2. Risk factors for complications developing during catheterization

	Complication (+) n:6	Complication (-) n:122	p
Gender			
Female (%)	4 (66.7)	2 (33.3)	45 (36.9)
Male (%)	77 (63.1)	0.054	0.054
Presence of underlying disease (%)	1 (16.6)	51 (41.8)	0.079
Presence of malnutrition (%)	1 (16.6)	21 (17.2)	0.388
Age (months, median)	55	21	0.319

Table 3. Comparison of subclavian catheter and femoral catheter groups

	Subclavian catheter n=37	Femoral catheter n=88	p
Chronic disease (%)	16 (43.2)	43 (%48.8)	0.566
Malnutrition (%)	6 (16.2)	15 (%17.4)	0.982
Gender, male (%)	17 (45.9)	31 (%35.2)	0.160
Mean patient age (months)	52.4±71.1	45.2 ± 47.3	0.544
PIM score (mean±SD)	36.5±36.4	34.7 ±31.5	0.796
PRISM score (mean±SD)	38.0±31.8	32.2 ±32.5	0.411

Table 4. Relationship between the catheter site and development of complications

Complication	Subclavian catheter n=37	Femoral catheter	p
Dwell time of the catheter, days (median)	7.5	10	0.62
Complication during catheterization, n (%)	1 (2.7)	5 (5.7)	0.624
Accidental dislocation, n (%)	0	2 (2.3)	0.447
Catheter exit site infection, n (%)	2 (5.4)	3 (3.4)	0.603
Catheter-related bloodstream infection, n (%)	3 (8.1)	4 (4.5)	0.429
Thrombosis, n (%)	0	6 (6.8)	0.103
Removal of catheter due to complication, n (%)	3 (8.1)	10 (11.4)	0.586

nutritional support. 73 of the catheters (57%) were removed because the requirement was eliminated. 13 catheters (10.1%) were removed because complications developed.

Six (4.7%) complications developed during catheterization (two arterial puncture, two hematomas, one arythmia, one pneumothorax). Pneumothorax occurred during subclavian vein catheterization and the other complications occurred durin femoral vein catheterization.

20 complications (15.6%) developed during catheter monitoring (seven catheter-related bloodstream infections, five catheter exit site infections, six thrombosis, two accidental dislocations). All complications of thrombosis and infection were observed during catheterizations lasting more than one week.

Analysis of the risk factors related to complications developing during catheterization is shown in Table 2. No statistically significant difference was found between groups in any of these analyses (p>0.05).

A statistically significant difference was not found between the properties of the subjects in whom femoral and subclavian catheters were inserted (p>0.05) (Table3). Since jugular vein catheterization was performed in only three subjects, no evaluation was done for this group.

No significant difference was found between femoral catheter and subclavian catheter groups in terms of development of complications (p>0.05) (Table 4).

Discussion

Central venous catheterization plays an important role in the management of the critical patient. With this method hemodynamic monitoring and extracorporeal treatments including plasmapheresis and hemodialysis as well as an appropriate venous line for administering medications are provided. Percutaneous central venous catheterization is a frequently performed intervention in intensive care units (1,2). However, clinical studies evaluating CVC interventions and their complications in pediatric intensive care units in Turkey are very limited in PubMed medical information Access database (www.ncbi.nlm.nih.gov/pubmed) (1,2). In Turkey Reference Index (www.atifdizini.com), no publication could be found on this subject. Therefore, we believe sharing our experience about CVC interventions and complications in our Pediatric Intensive Care Unit will contribute to Turkey's data.

When compared with adults, percutaneous central venous catheterization is technically more difficult and risky

in children (4,5). In our study, all catheterization efforts were ended with success (100%). Hematoma developed during catheterization only in two subject and the site of the catheter had to be changed. We think the fact that all catheterizations were performed in appropriate conditions, all subclavian catheterizations and risky femoral catheterizations were performed by pediatric intensive care specialists and other catheterizations were performed by senior research fellows under guidance of specialists played an important role in these successful results. Studies have shown that rates of success and complications for catheterization are related to the age and weight of the patient, urgency and appropriateness of the procedure and the experience of the operator (6,7). Some studies noted that complications during catheterization were not related to the age and weight (8-10). In our study, no relation was found between complications which occurred during catheterization and age and presence of malnutrition.

In our study, a total of six (4.7%) complications including two arterial punctures, one aryhtmia and one pneumothorax occurred during a total of 128 catheterizations. This rate ranges between 0.3% and 22% in the literature (11-14). Early complications which require surgical intervention are reported with a rate of 2-3% in the literature (15,16). Rey at al.(8) reported this rate to be 0.5%. In our study, no complication requiring surgical intervention was observed. Arythmia which was observed only in one subject in our study (0.8%) was considered as a severe complication and improved in a short time when the guide wire was removed. The low rate of complications during catheterization was attributed to the experience of our team as well as to the fact that all patients were on mechanical ventilator and received appropriate sedation and analgesia.

Each site selected for catheterization has advantages and limitations (2). Some authors note that subclavian vein catheterization is appropriate for long-term catheterization especially beacuse rates of colonization and infection are lower (17,18). Some other authors recommend femoral vein catheterization because of reasons including easy anatomic access, guidance of femoral arterial pulse, easy hemostasis even if arterial injury occurs, not constituting an obstacle for cardiopulmonary resuscitation, not having risks of hemothorax and penumothorax (19,20). In our study, femoral catheterization which we thought we could perform more easily and rapidly was predominantly preferred (68.8%).

In the literature, due to technical difficulty, complications are reported with a higher rate for subclavian and jugular vein catheterizations compared to femoral vein catheterization (21-23). However, in our study, five of six complications which occurred during catheterization were observed during femoral catheterizations, though the difference was not statistically significant. We believe that this can be explained by the facts that the number of subclavian interventions were small, all subclavian interventions were performed by experienced specialists under appropriate conditions and the difference of technical difficulty was decreased under deep sedation and analgesia on mechanical ventilator.

Complications observed during catheterization included arterial puncture, hematoma, arythmia, wrong insertion, pneumothorax and hemothorax (2,5,8). In the literature, the rate of arterial puncture during catheterization ranges between 1.9%-12.8% and the rate of hematoma ranges between 1.4% and 5.2% (1,2,8,10,13). In our study, arterial puncture and hematoma were observed with the same rate (1.5%) and all were observed during femoral intervention. Both bleeding which occurred after arterial puncture and hematoma could be easily controlled by applying pressure.

Arythmia developing during catheterization was reported with a rate of 0,3% in one study and with a rate of 2.3% in another study and mostly during subclavian intervention (8,13). However, arhthmia developed in one patient (0.8%) during femoral catheterization in our study. We thought this was related to the young age of the patient (3 months) and excessive pushing of the guide wire. Arythmia was not observed in any patients during subclavian vein catheterization.

The most frequent and severe complication during subclavian vein catheterization is reported to be pneumothorax. The frequency ranges between 1.2% and 6% in different studies and it usually does not require intervention. It is generally observed in interventions performed in the right side and can rarely develop 12-24 hours after the procedure and even 10 days later (2,5,24-26). In our study, pneumothorax developed only in one patient after subclavian vein catheterization. No intervention was performed, since the patient had no signs or symptoms and improvement was observed 2 days later.

The rate of complications in follow-up of patients in whom CVC is inserted ranges between 7% and 42% in differen publications (1,6,13,27). In our study, this rate was found to be 15.6% (thrombosis, infection, accidental dislocation). Sepsis and thrombosis among these complications require removal of the catheter (13). The catheters was removed in 13 patients in whom trombosis and catheter-related bloodstream infection were observed during follow-up. In our study, only two femoral vein catheters were dislocated accidentally during follow-up. In the literature, the rate of accidental dislocation has been reported to be higher (1,10,13).

Studies report the rate of catheter-related thrombosis determined by ultrasonography to be 33-67% for catheters dwelling for longer than one week (28,29). Karapınar et al. (1) reported this rate to be 2.1% in patients in whom CVC was inserted and Casado-Flores et al (13) reported this rate to be 2.7%. Investigators reported that this difference was due to the fact that diagnostic tests were done only in symptomatic patients. In our study, Doppler ultrasonography was performed only in symptomatic patients and the rate of thrombosis was found to be 4.6%. The rate of thrombosis related to femoral catheter is reported to be higher compared to the rate of thrombosis related to internal jugular catheterization (13,30). In our study, all of the six

cases of thrombosis occurred in patients in whom femoral catheter was inserted. As the dwelling time of femoral catheter increases, the risk of thrombosis increases. Therefore, it should be specifically emphasized that femoral vein should be preferred for short-term catheterizations (1). All of our catheter-related thrombosis cases were observed after the first week. No other risk factor was found in our patients in whom thrombosis developed. Some authors reported that ultrasonographic examination performed two time a week to monitor thrombosis in femoral catheterization lasting more than 5 days would be an efficient method for prevention of development of complication (31,32).

Catheter-related bloodstream infection was found with a rate of 5.5% in our study. This rate ranges between 3.7% and 40% in the literature because of use of different definition criteria (6,33). Mostly coagulase negative staphylococci have been reported in catheter-related infections in publications and it has been noted that as the dwelling time of the catheter increases, the risk of infection increases (2,13). In contrast to the literature, mostly gram negative bacilli were found in catheter-related bloodstream infections in our study. It was also observed in our study that as the dwelling time of the catheter increased, the frequency of infection increased. In accordance with the literature, no difference was found between femoral and subclavian sites in terms of development of catheter-related bloodstream infection in our study (6,13,20).

Consequently, CVC which is necessary for monitoring and treatment of critically ill children in pediatric intensive care units is an easy intervention with a low rate of complication in experienced hands. However, the patient's clinical properties and the interventional experience of the physician with that vein should be considered in selecting the vein for intervention.

Conflict of interest: None declared.

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