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Complications in Percutaneous and Surgical Insertion of Tunneled Central Venous Catheters for Pediatric Patients

Çocuk Hastalarda Tünelli Santral Venöz Kateterlerin Perkütan ve Cerrahi Yerleştirilmesindeki Komplikasyonlar

Gülsen Keskin
Mine Akın
Sibel Saydam
Sengül Özmert
Devrim Tanıl Kurt
Ervin Mambet
Emrah Şenel
Melike Kaya Bahcecitapar

ABSTRACT

Objective: *Percutaneous insertion of permanent tunneled catheters, accompanied by ultrasonography (USG) guidance, has established itself as practical, safe, and widely used procedure. The purpose of our study; To examine and compare the complications associated with permanent tunneled catheters placed by percutaneous or open surgical method in pediatric hemato-oncology patients.*
Methods: *Medical records of 101 pediatric patients from the ASA 3-4 group who were placed in a Hickman-type tunneled central venous catheter for bone marrow transplantation between 2013 and 2015 in our clinic were retrospectively reviewed. Demographic data of the patients, catheter insertion location, size, complications encountered during and after the intervention, and reasons for catheter removal were recorded.*
Results: *One hundred and one tunneled central venous catheters were placed percutaneously under USG guidance in 54 patients, and using open technique in 47 patients. Patients in both groups were similar in terms of age, height, weight, size of the inserted catheter, duration of catheterization, and reasons for removal. No difference was found between percutaneous and surgical groups in terms of intraoperative and postoperative to technique, and infective complications related to catheter.*
Conclusion: *In pediatric hemato-oncology patients, there is no difference in terms of intraoperative, and postoperative complications between percutaneous technique and open technique for permanent tunneled central catheter insertion. Both techniques can be used with low complication rates, and the percutaneous technique may be preferred because it is less invasive.*

Keywords: *Children, central venous catheters, permanent tunneled, hematology-oncology, complications*

ÖZ

Amaç: *Kalıcı tünelli kateterlerin ultrasonografi (USG) rehberliğinde perkütan olarak yerleştirilmesi, pratik, güvenli ve yaygın kullanılan bir girişimdir. Çalışmamızın amacı; pediyatrik hemato-onkoloji hastalarında perkütan veya açık cerrahi yöntem ile yerleştirilen kalıcı tünelli kateterlere bağlı komplikasyonları incelemek ve karşılaştırmaktır.*
Yöntem: *Kliniğimizde, 2013-2015 yılları arasında, kemik iliği nakli için Hickman tipi tünelli santral venöz kateter yerleştirilen, ASA 3-4 grubundan 101 pediyatrik hastanın tıbbi kayıtları geriye dönük olarak incelendi. Hastaların demografik verileri, kateter yerleştirme yeri, boyutu, girişim sırasında ve sonrasında karşılaşılan komplikasyonlar ve kateter çıkarılma nedenleri kaydedildi.*
Bulgular: *Yüz bir tünelli santral venöz kateterin, 54 hastada USG rehberliğinde perkütan olarak, 47 hastada ise açık teknik kullanılarak yerleştirildiği tespit edildi. Her iki gruptaki hastalar yaş, boy, kilo, takılan kateter boyutu, kateterizasyon süresi ve çıkarılma nedenleri açısından benzerdi. Kateter ile ilişkili intraoperatif ve postoperatif teknik ve enfektif komplikasyonlar açısından perkütan ve cerrahi gruplar arasında fark bulunmadı.*
Sonuç: *Pediyatrik hemato-onkoloji hastalarındaki kalıcı tünelli kateter girişimlerinin, perkütan teknik ve açık teknik ile uygulanması arasında intraoperatif ve postoperatif komplikasyonlar açısından fark bulunmadı. Her iki teknik de düşük komplikasyon oranları ile kullanılabilir, perkütan teknik daha az invazif olduğu için tercih edilebilir.*

Anahtar kelimeler: *Çocuk, santral venöz kateter, kalıcı tünelli, hematoloji-onkoloji, komplikasyonlar*

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Gülsen Keskin
Sağlık Bilimleri Üniversitesi,
Dışkapı Yıldırım Beyazıt
Eğitim ve Araştırma Hastanesi,
Anesteziyoloji ve Reanimasyon Kliniği,
Ankara - Türkiye
✉ drgulsenkeskin@gmail.com
ORCID: 0000-0002-9990-5533

M. Akın 0000-0002-1380-0256
S. Saydam 0000-0003-1649-8205
S. Özmert 0000-0001-9545-5283
D. Tanıl Kurt 0000-0002-8330-504X
Ankara Şehir Hastanesi,
Anesteziyoloji ve Reanimasyon Kliniği,
Ankara, Türkiye

E. Mambet 0000-0002-2433-2451
Sağlık Bilimleri Üniversitesi,
Gülhane Eğitim ve Araştırma
Hastanesi, Çocuk Cerrahisi Kliniği,
Ankara, Türkiye

E. Şenel 0000-0002-0383-4559
Ankara Yıldırım Beyazıt
Üniversitesi, Tıp Fakültesi,
Çocuk Cerrahisi Anabilim Dalı,
Ankara, Türkiye

M. Kaya Bahcecitapar 0000-0002-5443-6278
Hacettepe Üniversitesi
Fen Fakültesi, İstatistik Bölümü,
Ankara, Türkiye

INTRODUCTION

A tunneled central venous catheter creates a tunneled road away from the vascular access point, a path that provides central venous access and that can be used for a period of time longer than other temporary venous access catheters, such as peripheral intravenous cannulas, peripherally placed central catheters, or non-tunneled central venous catheters. Tunneled central venous catheters, besides offering the advantage of long-term use, reduce the risk of infection and provide the option of sending medicine via infusion [1,2]. Because of these clinically important benefits, tunneled catheters are commonly applied in pathological conditions that require long-term treatment, such as oncological diseases, dialysis requirements, chronic diseases, and nutritional support.

However, like all other invasive procedures, adverse events may occur during the insertion or use of these catheters. Any procedure where the skin is punctured potentially carries the risk of infection. There may be significant bleeding, hematoma, or pneumothorax during the procedure. Technical problems related to the catheter such as dislocation, breakage, or blockage of the lines may also occur [3,4].

In this study, we aimed to investigate the complication rates of tunneled central venous catheters inserted by anesthesiologists using the percutaneous technique and by surgeons using the open surgical technique. Our second aim was to determine whether these complication rates are different in children under 20 kg.

MATERIAL and METHODS

After obtaining approval from the hospital ethics committee (03.08.2015; 2015-037) at the Ankara Child Health-Diseases Hematology and Oncology Education Research Hospital and verbal informed consent from parents over the phone, a single center retrospective review was performed on patients who had undergone Hickman catheter insertion. All patients who underwent tunnel central venous catheter placement (ASA 3-4) for bone marrow transplantation between 2013 and 2015 were included in the study. These patients' medical records were examined retrospectively. Data on demographic profile, technique used, and site, type, and size of catheter were collected. Complications during and after the procedure were classified and recorded.

Hickman type (Medcomp®, 90 cm, double lumen silicone catheter, USA) catheters were used and all catheter placement procedures were performed in the operating room with general anesthesia, and local anesthesia was provided for analgesia. The patients were placed supine with a small roll under the patient's shoulders in the Trendelenburg position to fill the neck veins. The Hickman catheter was placed in the internal jugular vein by the anesthesiologist using a percutaneous technique, under the guidance of ultrasound (Sonosite Mikromaxx®, USA). The vessel selected was punctured under ongoing ultrasound guidance, and the tip of the needle was seen in the lumen. The guidewire was advanced to the right atrium/superior vena cava junction, and the dilator was passed over the guidewire using the Seldinger technique. Dilator placement was observed with fluoroscopy to minimize potential complications. The guidewire was removed and the catheter inserted by sliding it over the guidewire. The preferred catheter tip position is in the lower superior vena cava or right atrium junction, and correct placement was confirmed by intraoperative fluoroscopy, aspiration, catheter flushing, and postoperative chest radiograph.

Percutaneous catheter placement procedures were performed by anesthesiology specialists of differing levels of seniority. All surgical placement procedures were performed by the same pediatric senior specialist surgeon using the open technique, which calls for a skin incision over the external jugular vessel. A venotomy was made, and the central access catheter was inserted under direct vision.

The same fixation methods and postoperative catheter care procedures were applied in both placement techniques. Central catheters were tunneled under the skin to the anterior chest wall. Fully implantable venous access devices were fixed to the pectoral fascia in the subcutaneous pocket with sutures. After both procedures, pediatric hematology service nurses continued catheter care.

Statistical analysis

All statistical analyses were performed using IBM SPSS 22.0 for Windows. In order to describe the basic features of the data, the number of cases and proportions were used for categorical variables and mean, standard deviation and range were calculated for continuous variables. Binary logistic regression analysis was also used to analyze the appearance of complication (yes/no), catheter culture (negative/positive), and blood culture (negative/positive). Pearson chi-square, continuous continuity test or Fisher's exact test were used to compare the percutaneous and surgical groups according to categorical variables such as gender, weight groups, anatomic sites for procedure, as well as others. Additionally, the same analyses were used to assess the association between weight groups and categorical variables. The Mann-Whitney U test or two sample t-test were also used to compare percutaneous and surgical groups for age, weight, height, and duration of catheterization. A p-value<0.05 from two-sided tests was considered statistically significant.

RESULTS

A total of 101 patients were included in the study, of which 54 underwent percutaneous placement by the anesthesiologist, and 47 underwent open procedure performed by the surgeon.

The mean age was 9.21±4.54 years (interquartile range 0.6 to 17 years), and mean weight was 29.18±15.68 kg (interquartile range 4 to 90 kg). There was no statistically significant difference between the groups in terms of age, weight and height (p>0.05). Table I presents demographic data and information on catheter insertion of the groups and all patients.

A total of 47 procedures were performed using the open technique and, 54 using the USG percutaneous technique. None of the percutaneous insertions required conversion to open technique, and no percutaneous insertions were performed without ultrasound guidance. Among the intraoperative complications observed, hemothorax, pneumothorax, arte-

Table I. Demographic and catheter insertion data of the groups.

Demographic data	Total		Percutaneous		Surgical		
Number of cases(n)	101		54		47		
	n	%	n	%	n	%	p†
Gender							0.896
Male	63	62.4	34	63.0	29	61.7	
Female	38	37.8	20	18.0	18	38.3	
Weight							0.588
≤20 kg	38	37.6	19	35.2	19	40.4	
>21 kg	63	62.4	35	64.8	28	59.6	
Catheter size							-
7F	36	35.6	16	29.6	20	42.6	
9.5F	45	44.6	26	48.1	19	40.4	
11F	15	14.9	8	14.8	7	14.9	
12F	5	5.0	4	7.4	1	2.1	
Anatomic site for procedure							<.001**
Right internal jugular vein	62	61.4	51	94.4	11	23.4	
Right external jugular vein	15	14.9	.	.	15	31.9	
Left internal jugular vein	10	9.9	3	5.6	7	14.9	
Left external jugular vein	14	13.9	.	.	14	29.8	
Removal causes indications							-
Infection (catheter entry site skin infection, or positive blood or catheter culture)	29	28.7	17	31.0	12	25.6	
End of the therapy	62	61.4	27	50.0	35	74.5	
Leak	3	3.0	2	3.7	1	2.1	
Death	7	6.9	5	9.3	2	4.3	
How many times of catheter insertion							0.065
1	93	92.1	47	87.0	46	97.9	
2	8	7.9	7	13.0	1	2.1	

*Variables are presented as number (%), †:chi-square test, -:chi-square assumptions not met, *:p<0.05, **:p<0.01*

Table II. Catheter related complications.

	Total		Percutaneous		Surgical		
Number of cases	**n = 101**	**%**	**n = 54**	**%**	**n = 47**	**%**	**p†**
Bleeding during procedure	3	3.0	2	3.7	1	2.1	1.000
Hematoma after the procedure	1	1.0	1	1.9	0	0.0	1.000
Thrombosis	2	2.0	1	1.9	1	2.1	1.000
Incorrect placement	2	2.0	2	3.7	0	0.0	0.621
No blood return	2	2.0	2	3.7	0	0.0	0.621
Positive catheter culture	7	6.9	5	9.3	2	4.3	0.445
Positive blood culture	12	11.9	8	14.8	4	8.5	0.373

†:chi-square test

Table III. Complications rates and weight relationship (≤ 20 kg and > 20 kg) for groups and all patients.

	Percutaneous			Surgical		
	Weight≤20	**Weight>20**	**p†**	**Weight≤20**	**Weight>20**	**p†**
Number of cases	19	35		19	28	
Bleeding during procedure	1 (5.3)	1 (2.9)	1.000	1 (5.3)	0 (0.0)	0.561
Hematoma after the procedure	1 (5.3)	0 (0.0)	0.547	.	.	-
Thrombosis	1 (5.3)	0 (0.0)	0.547	0 (0.0)	1 (3.6)	1.000
Incorrect placement	1 (5.3)	1 (2.9)	1.000	.	.	-
No blood return	2 (10.5)	0 (0.0)	0.130	.	.	-
Infection	6 (31.6)	7 (20.0)	0.412	5 (26.3)	1 (3.6)	0.056
Overall complications	14 (73.7)	24 (68.6)	0.694	6 (31.6)	9 (32.1)	0.968

*Variables are presented as number (%), -:chi-square assumptions not met, *:p<0.05, †:chi-square test*

rial puncture, pericardial effusion, inability to reach the intended vein did not occur in either group, so they were not included in the tables. While mostly internal vascular structures were used in the percutaneous group, external vein usage was more common in the surgical group. The mean duration of catheterization of all patients was 69.51±38.06 days. There was no significant difference between percutaneous and surgical groups (70.4±30.1 & 68.5±45.8 days respectively) (p=0.21>0.05).

No difference was found between the percutaneous and surgical groups in terms of catheter-related intraoperative and postoperative technical, infective, or other complications (Table II). Children under 20 kg and over 20 kg in each group were carefully evaluated to establish whether there were differences in lower weight patients in terms of complications, and no difference was observed (Table III).

According to the binary logistic regression analysis, duration of catheterization, catheter sizes, and patient weight do not have a significant effect on any complication or positive blood culture or positive catheter culture development in patients (p>0.05).

DISCUSSION

This study examined percutaneous and surgical Hickman catheter placement methods in children with hematological cancers requiring bone marrow transplantation. We evaluated complications that developed during and after insertion of the catheter during interventions of both catheterization methods, finding no difference in complication development between the two. Similarly, complication rates did not differ in patients under and over 20 kg.

A number of complications may occur during and after tunneled central venous catheter placement. The occurrence of complications may relate to the physician's level of experience, the patient's characteristics, and the procedure itself [5]. The most basic technical complications in catheterization include difficulty advancing the catheter through the sheath, catheter kinking, and accidental arterial puncture. None of these were encountered in our study. Likewise, we did not observe mechanical complications such as pneumothorax or hemothorax. We also did not encounter any instance of a return from the percutaneous to the open surgical method.

Venous access is sometimes not possible during catheter placement, and often occurs when the vessel is blocked or stenotic in patients who previously had catheters. We examined the success rate of catheter insertion upon first or second attempt and found no significant difference between the percutaneous and surgical groups. Failure to achieve the desired venous access, resulting in incorrect placement, was observed in two (3.7%) patients in the percutaneous group and none in the surgical group. After the procedure, the absence of blood backflow from one end of the catheter was detected in two patients in the percutaneous group, despite the fact that the catheter's location was fluoroscopically confirmed and blood was obtained from the other route. Blum [6] reported higher failure rates than those of the present study, with 4% incorrect placement in percutaneous procedures and 4.9% in the surgical group. Ahmed [7] reported 5% in the percutaneous group and 4% in the surgical group. Although percutaneous group patients had similar incorrect placement rates in ours and the studies mentioned above, this measure was higher in the surgical groups in the other studies than in our study. In fact, placement problems and technical complications are less expected in the surgical groups for the simple reason that the procedure is done in the open. Misplacement in percutaneous procedures is more likely due to both the difficulty of the patient's anatomy and the fact that USG gives a 2-dimensional image. The rate of technical and mechanical complications are frequently operator dependent and most are detected at the time of catheter insertion. Experience plays a crucial role here and complications are more common during procedures performed by clinicians still in the learning curve. The catheters of the surgical group patients in our study were inserted by a very experienced senior surgeon, and we consider this to be the explanation for the absence of any incorrect placements.

3.7% of participants in the percutaneous group and 2.1% in the surgical group experienced bleeding complications during the procedure, and 1.9% of participants in the percutaneous group experienced hematoma complications after the procedure. Blum et al. [5] reported these rates as 0.3% in the percutaneous group and 2% in the surgical group. Ayhan et al. [8] reported a bleeding rate of 8.6% with tunneled catheters, regardless of technique. Ahmed et al. [7] reported the rate of thrombosis complication as 9% in the surgical group and 7% in the percutaneous group. In Skladal et al. [9], thrombosis was observed in 7% of patients with percutaneous catheter insertion, and it has been suggested that its own thrombosis complication are less than other studies. The lower instance of thrombosis in that study was attributed to the catheters' placement at the upper third of the right atrium and not at the distal end of the vena cava superior. It seems that we have quite acceptable results in terms of bleeding and thrombosis complications. However, the issue of experience mentioned above is also relevant here, as bleeding may be more common in the percutaneous group because those procedures were performed by a less experienced group of clinicians.

Another important complication associated with long-term tunneled catheters are infective problems. Contamination during the procedure, insufficient drainage, patient movement during the procedure, or accidental contact of something with a guidewire or catheter outside the sterile field are important complications that can result from a variety of sources and subsequently lead to infection. In the present study, although there was no statistically significant difference, infectious complications were more common in the percutaneous group (positive catheter culture 9.3%, positive blood culture 14.8%) compared to the surgical group (positive catheter culture 4.3%, positive blood culture 8.5%). In Vierboom's study [1], there was an infection rate of 16.9% in the percutaneous group and 15.6% in the surgical group. In another study, the rate of infective complications was reported to be 17.7% in open surgical catheterization [10]. In Ahmed et al.'s study [7], the percutaneous technical group showed relatively low infection rates compared to the surgical group. Although the rates of infectious complication in our study are in line with those reported in the literature, more frequent infection in the percutaneous group is likely related to the experience of the operator. Clinicians inexperienced in subcutaneous tunneling may have concentrated on the procedure itself rather than asepsis, even though in this study standard asepsis conditions were fulfilled. It commonly understood that complications reduce when the clinician has

overcome the difficult learning curve and developed sufficient percutaneous technical experience [11]. In our study, percutaneous insertions were performed by anesthesiologists at different points along the learning curve, whereas open surgical insertions were performed by a single senior surgeon.

In our study, it was observed that the duration of catheterization, the size of the catheter, or patient weight did not have any relation with complications. When the patients weighing at or under 20 kg were evaluated separately, no difference was observed in either technical or infective complications. Although some researchers claim that catheter size and patient weight lead to higher complications [12], others do not find a difference similar to us when the complications are evaluated in children both under 5 kg and under 10 kg [1].

Our study investigated catheterization among patients with hematological malignancies requiring bone marrow transplantation. Although some researchers claim that tumor types may have an effect on complications such as thrombosis or bleeding [13], we did not evaluate tumor types in detail. Another limitation of our study is that we were unable to obtain the duration of the procedure. We therefore were unable to evaluate the relationship between the duration of the procedure and complications, especially the development of infection.

Nowadays, in most clinics highly experienced interventional radiologists and anesthesiologists have taken over the job of inserting permanent catheters. Permanent tunnel catheter insertion, accompanied by USG using the percutaneous method, has established itself as a very practical and safe procedure. The open method with surgery is rarely used except for technically difficult and anomalous cases. The challenge facing increased adoption of the percutaneous procedure, however, revolves around complications arising from inexperience. The clinician still in the process of learning may focus more on technique and neglect other procedural circumstances. Therefore, a senior controller should be with the physician, and careful attention should be placed on every step of the procedure, especially asepsis.

CONCLUSION

As a result, no difference was found in pediatric patients between the percutaneous technique performed by anesthesiolog and the open technique performed by surgeon. We can say that variables such as patient weight, catheter size, catheter duration have no effect on complications during and after the procedure. The complication rates were not different in children under 20 kg and 20 kg over. With these results, we can assert that it is safe to apply the percutaneous technique in all patients. We believe that it would be beneficial to emphasize every step of the procedure, especially during the learning curve, whether carried out by an anesthesiolog or a surgeon.

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