

Catheter Malposition as a Considerable Complication of Central Venous Catheterization: An Analysis of 23 Cases in a Tertiary Referral Hospital

Santral Venöz Kateterizasyonun Önemli Bir Komplikasyonu Olarak Kateter Malpozisyonu: Üçüncü Basamak Sevk Hastanesinde 23 Olgunun Analizi

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Abstract

Objectives: We aimed to present the clinical characteristics of patients with catheter malposition following central venous catheterization, and to review the relevant literature.

Materials and Methods: A total of 1816 patients who underwent central venous catheterization via internal jugular or subclavian vein in a tertiary referral hospital between January 2011 and December 2018 were researched for this cross-sectional study. Among them, procedure-related catheter malposition was detected in 23 cases, and the study population composed of these cases with catheter malposition. Medical data of study population were obtained and retrospectively reviewed.

Results: The rate of catheter malposition following central venous catheterization was 1.26%. The mean age of the study population was 55.1 ± 21.3 years, and 52.2% of them were male. The blind-landmark technique without ultrasound guidance was the selected approach in 21 of cases (91.3%). In study population, additional procedure-related complications were subcutaneous hematoma, pneumothorax, and hemo-pneumothorax in six, three and two cases, respectively. In-hospital death was observed in two cases because of the causes other than procedure-related complications.

Conclusion: Catheter malposition is a relatively lesser encountered but an important complication of central venous catheterization. We suggest that during central venous catheterization, the radiological-guided approach should be of choice instead of the blind-landmark technique to minimize the risk of catheter malposition.

Key Words: Catheter Malposition, Central Venous Catheterization, Complication, Adverse Event

Öz

Amaç: Bu çalışmada santral venöz kateterizasyon sonrası kateter malpozisyonu olan hastaların klinik özelliklerini sunmayı ve ilgili literatürü gözden geçirmeyi amaçladık.

Gereç ve Yöntem: Ocak 2011 - Aralık 2018 tarihleri arasında üçüncü basamak bir sevk hastanesinde internal juguler veya subklavyen ven yoluyla santral venöz kateterizasyon uygulanan toplam 1816 hasta bu kesitsel çalışmada değerlendirildi. Bunlardan 23 olguda işleme bağlı kateter malpozisyonu tespit edildi ve çalışma popülasyonu kateter malpozisyonu olan bu olgulardan oluşturuldu. Çalışma popülasyonunun tıbbi verileri elde edildi ve geriye dönük olarak incelendi.

Bulgular: Santral venöz kateterizasyon sonrası kateter malpozisyon oranı %1,26 idi. Çalışma popülasyonunun ortalama yaşı $55,1 \pm 21,3$ yıl idi ve %52,2'si erkekti. Olguların 21'inde (%91,3) seçilen yaklaşım ultrason rehberliği olmaksızın kör nokta tekniği idi. Çalışma popülasyonunda, prosedüre bağlı diğer komplikasyonlar sırasıyla altı, üç ve iki olguda gözlenen subkütan hematoma, pnömotoraks ve hemopnömotoraks idi. İşlemle ilişkili komplikasyonlar dışındaki nedenlere bağlı hastanede ölüm iki olguda görüldü.

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Received/Geliş Tarihi: 11.11.2020 Accepted/Kabul Tarihi: 19.02.2021

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Journal of Ankara University Faculty of Medicine is published by Galenos Publishing House.

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Abstract

Sonuç: Kateter malpozisyonu, nispeten daha az karşılaşılan ancak santral venöz kateterizasyonun önemli bir komplikasyonudur. Santral venöz kateterizasyon sırasında, kateter malpozisyon riskini en aza indirmek için kör nokta tekniği yerine radyolojik kılavuzlu yaklaşımın tercih edilmesi gerektiğini düşünüyoruz.

Anahtar Kelimeler: Kateter Malpozisyonu, Santral Venöz Kateterizasyon, Komplikasyon, İstenmeyen Olay

Introduction

Central venous catheterization (CVC) is an invasive procedure that is frequently applied for the treatment of total parenteral nutrition and hemodialysis as well as in complicated patients who required a large and safe vascular access. For these purposes, while internal jugular vein, subclavian vein and femoral veins are the most frequently accessed veins, external jugular vein, cephalic and basilic veins are the less frequently preferred (1-3). The success rate of CVC procedure has been reported to be between 75 and 99% (2,4-9). Although it is a relatively safe procedure, serious complications related to the procedure such as pneumothorax, hemothorax and vessel perforation are rarely encountered as well. The overall procedure-related complications have been reported to occur between 0-21% in various reports (4,6-9). Among the procedure-related complications, catheter malposition is a relatively lesser described but a significant complication of CVC insertion, in which the tip of the central catheter usually malpositioned into a vessel other than the superior vena cava (SVC).

The aim of this study was to present our experiences on the cases with catheter malposition following CVC via percutaneous internal jugular vein or subclavian vein. In addition, in this paper we also reviewed the existing literature in the light of current data.

Materials and Methods

Ethical considerations

This study was initiated after obtaining approval from the Bolu Abant İzzet Baysal University Clinical Researches Ethics Committee (date: 19.12.2019; decision number: 2019/320) and conducted in accordance with the principles of the Helsinki Declaration. Before the procedure, all patients were informed about the intervention and their informed procedural consents were obtained.

Study population and design

This study was a retrospective cross-sectional study conducted at a tertiary referral hospital in Turkey. In the study, we screened the medical data of our hospital, and detected that a total of 1816 adult patients underwent percutaneous CVC via internal jugular vein or subclavian vein from January 2011 to December

2018. We observed that 23 cases had malpositioned CVC via the routine screening the posteroanterior chest radiographs at post-catheterization period, and these cases constituted our study population. For this study there were no described exclusion criteria and all these 23 adult cases with catheter malposition following CVC were included in this study. All medical data of the patients were screened via the computerized database of our hospital, and then recorded and retrospectively analyzed. For this study, catheter malposition was defined as catheter tip placement into a vein other than SVC or right atrium which detected at the postprocedural routine chest radiography scan.

Procedural approach

All interventions were performed under local or general anesthesia with sterile conditions in the intensive care unit or operating room. Patients' non-invasive arterial blood pressure, electrocardiography and fingertip oxygen saturation were monitored before the intervention. After the proper body position was provided, the right or left internal jugular vein or subclavian vein were percutaneously punctured using Seldinger needle through either blind landmark technique or ultrasound guidance. After a sufficient amount of blood was withdrawn into the syringe, a guidewire was progressed into the central vein through Seldinger needle. Afterwards, the CVC was inserted into the target vessel through the guidewire. After the procedure was completed, in order to check the position of the catheter, a posteroanterior chest radiograph was routinely obtained from all patients undergoing CVC. Hereby the catheter malposition was detected if present. Examples of chest radiograph of patients with central catheter malposition are shown in Figure 1.

Statistical Analysis

Data were assessed with using Statistical Package for Social Sciences version 20.0 (SPSS Inc., Chicago, Illinois, USA). Continuous variables were presented as mean $\pm$ standard deviation. Categorical variables were expressed as frequency and percentage.

Results

Twenty one of 23 cases (91.3%) were punctured through blind landmark technique without ultrasound guidance while only 2 cases (8.7%) received an ultrasound guidance during the catheterization; thus, we were not able to perform a

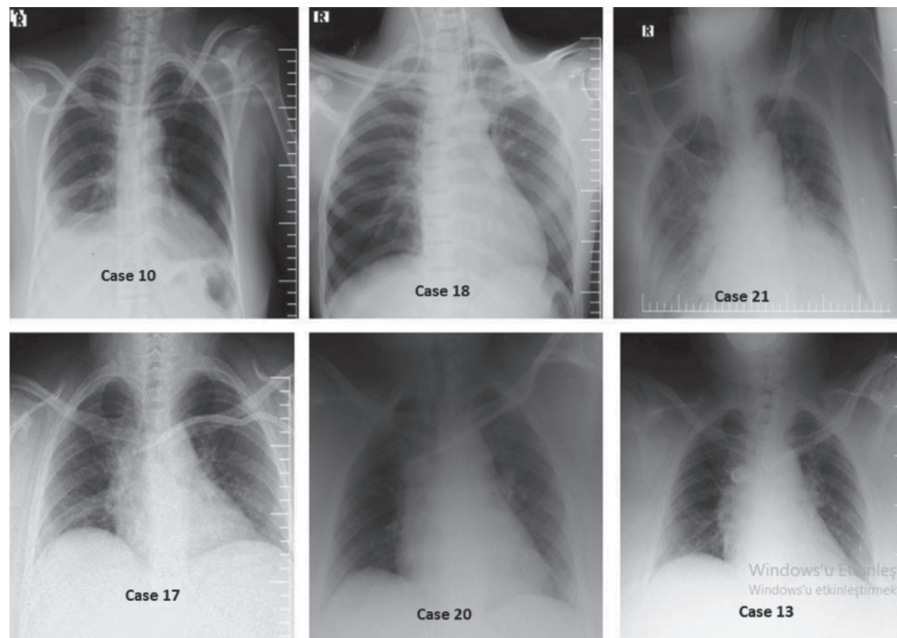


Figure 1: X-ray images of patients with catheter malposition

comparative analysis between the cases with and without ultrasound guidance. Overall procedure-related catheter malposition rate was 1.26% (n=23/1816). Mean age of the cases with catheter malposition was 55.1 ± 21.3 years (range: 19-87 years), and 12 (52.2%) of patients were male. The most common diagnoses of these cases were chronic renal failure in 8 cases and malignancy in five cases. Inserted CVC types were short-term CVC in nine cases, temporary or permanent (tunneled) hemodialysis catheters in 9 cases, and totally implantable venous-access port catheter in remaining five cases. Mean length of hospital stay was 5.2 ± 5.5 days (range: 1-22 days). In this patient group the most common occurred complication related to CVC was superficial hematoma, which was observed in six cases. Other complications related to the procedure were pneumothorax in three cases and hemopneumothorax in two cases. In-hospital mortality occurred in two cases due to causes other than CVC associated complications. Clinical characteristics of patients with central catheter malposition are summarized in Table 1.

Discussion

In the current study, we presented the clinical features of 23 cases with catheter malposition among 1816 patients inserted CVC via percutaneous internal jugular vein or subclavian vein, and shared our experiences in the relevant topic. In this case series, we witnessed that catheter malposition could occur in many different and atypical localizations. Furthermore, we detected that the majority of cases with catheter malposition (91.3%) had a venous access with blind-landmark technique

without ultrasound guidance, and just two of all cases with catheter malposition (8.7%) received radiological guidance during CVC insertion. Therefore, we suggest that the radiological guidance during CVC insertion are of utmost importance and necessary to prevent catheter malposition, although we did not conduct a comparative analysis between blind-landmark technique and radiological-guidance approach and could not obtain quantitative evidence.

The first application of CVC was performed for intravenous fluid administration and parenteral nutrition by Aubaniac (10) in 1952. Since then the CVCs have become gradually more available and implantable because they provide safer and longer-term venous access; and nowadays, CVC has become a commonly-performed invasive procedure in contemporary clinical practice. Nevertheless, in spite of these benefits of CVCs, CVC insertion has a dangerous potential of complications including catheter malposition, migration and embolization, pneumothorax, hemothorax, air embolism, vascular injury, perforation and even tamponade (1-9). Among these serious and life-threatening complications, a relatively less defined but a very important complication of CVC is the malposition of catheter tip into a vessel other than the SVC.

Catheter malposition is defined as catheter tip placement into a vein other than SVC or right atrium, impingement with lateral wall of SVC ($>40^\circ$) or arterial cannulation (11,12). The frequency of catheter malposition has been reported to be between 1.4 and 11.2% in the large-scale studies in the literature (4,13-15). In the applications of central catheterization at our center, procedure-related catheter malposition rate (1.26%)

was acceptable and even lower as compared to the rates of the literature. If not addressed, catheter malposition may cause several adverse events such as venous thrombosis, erosion and perforation of vessel wall, catheter wedging and dysfunction. In

fact, as stated by Roldan and Paniagua (11), catheter malposition is not a complication of central catheter insertion, nevertheless its underdiagnosis or delayed treatment can be associated with significant morbidity and even death.

Table 1: Clinical characteristics of the patients

Patient	Age	Gender	Primary diagnosis	Type of CVC	Puncture	Punctured vein	Location of catheter tip	Complications related to CVC	Length of hospital stay (day)	Mortality
1	47	Female	Malignancy	TIVAP	Blind	RSV	RAV	Hematoma	2	No
2	55	Female	Malignancy	TIVAP	US-guided	RSV	LJV	No	1	No
3	70	Male	Malignancy	TIVAP	Blind	RSV	RICV	No	1	No
4	82	Male	Malignancy	TIVAP	Blind	LSV	RSV	No	2	No
5	33	Male	CRF	Temporary HD	Blind	RJV	LJV	No	2	No
6	78	Female	CRF	Temporary HD	Blind	LSV	LICV	Hematoma, Hemo-pneumothorax	3	Yes
7	62	Male	CAD	Short-term CVC	Blind	RJV	RSV	No	8	No
8	74	Female	ARF	Short-term CVC	Blind	RJV	RICV	Pneumothorax	13	No
9	51	Female	Subdural hematoma	Short-term CVC	Blind	RSV	RIMV	No	10	No
10	49	Female	Hypercalcemia	Temporary HD	Blind	RSV	LSV	No	7	No
11	83	Male	Pericardial effusion	Short-term CVC	Blind	RJV	LSV	Hematoma	5	No
12	74	Male	ARF	Short-term CVC	Blind	LJV	LSV	No	6	No
13	27	Female	Epidural hematoma	Short-term CVC	Blind	LSV	RSV	No	15	No
14	87	Female	Intoxication	Short-term CVC	Blind	RSV	LICV	Pneumothorax	22	Yes
15	19	Male	CRF	Temporary HD	Blind	RSV	LJV	No	1	No
16	47	Male	CRF	Permanent HD	Blind	LJV	LSV	No	1	No
17	42	Female	CRF	Permanent HD	Blind	LSV	RSV	No	1	No
18	20	Male	CRF	Permanent HD	Blind	RSV	RJV	No	1	No
19	25	Male	Gunshot injury	Short-term CVC	Blind	RSV	RICV	Hematoma, Hemo-pneumothorax	5	No
20	41	Female	CRF	Permanent HD	Blind	LSV	RICV	No	1	No
21	55	Male	CRF	Permanent HD	Blind	RSV	RJV	No	1	No
22	77	Male	Malignancy	TIVAP	Blind	LSV	RSV	Hematoma	4	No
23	69	Female	CAD	Short-term CVC	US-guided	RJV	RSV	Hematoma	8	No

ARF: Acute respiratory failure, CAD: Coronary artery disease, CRF: Chronic renal failure, CVC: Central venous catheter, HD: Hemodialysis, LICV: Left intercostal vein, LJV: Left jugular vein, LSV: Left subclavian vein, RAV: Right axillary vein, RICV: Right intercostal vein, RIMV: Right internal mammary vein, RJV: Right jugular vein, RSV: Right subclavian vein, TIVAP: Totally implantable venous access port, US: Ultrasonography

The position of catheter tip is of great importance for safety and longer-term maintenance of CVCs. American Food and Drug Administration has reported that the catheter tip should not be placed or allowed to migrate into the heart (16). If a central catheter is placed into the right atrium or other cardiac cavities, it can lead to cardiac-related adverse events including dysrhythmias, intracardiac thrombosis, perforation, tamponade, and even death. Additionally, catheter tip placed into SVC can also lead to the catheter malfunction. It is recommended that the catheter tip should be positioned into the area of the junction of SVC and right atrium, as the ideal catheter tip position (11,17-19).

Predisposing factors of catheter malposition are as follows: Existence of congenital or acquired anatomical variations, catheter insertion in left thoracic venous system, methodological inaccuracy, inappropriate bevel orientation upon needle insertion, and difficult body habitus variants of patients (e.g., obesity or large breasts). Congenital variations in venous anatomy such as persistent left-sided SVC, and acquired factors such as venous thrombosis or stenosis, venous compression due to tumoral mass may result in catheter malposition. Catheter malposition is more commonly observed when the left internal jugular vein or left subclavian vein is cannulated. Increased malposition risk with the left-side central venous access is probably on account of existence of a long left brachiocephalic vessel, a more oblique course to the heart, and existence of small branches in this region. Appropriate bevel orientation upon needle insertion facilitates the progression of guidewire towards intended direction, and the guidewire plays a key role in steering the successful placement of the catheter. If the guidewire is unexpected to kink, entering in other vessel incorrectly, the catheter would tend to be malpositioned or obstructed after the guidance, even to other venous system, by following an abnormal path to neck, arm, thorax, or contralateral side. Moreover, the excessive force that is used inappropriately as the guidewire run out of vessel, may lead to the catheter pass into the mediastinum, pleura or other extravascular areas, which will bring out serious and lethal results (11,18).

Although the malpositioned central catheters have been reported to localize in almost every possible anatomical positions, catheter malposition most commonly occurs through subclavian vein cannulation in which catheter tip entrances into the internal jugular vein (14). During the percutaneous subclavian vein access, some measures can be taken to avoid the catheter malposition. When the subclavian vein cannulation is attempted, practitioners should make certain that the J-tip of the guidewire must be pointed caudad during insertion (20). Lateral flexion of the head toward the insertion side stretches and narrows the internal jugular vein, preventing the tip from entering the jugular venous circulation (21). Manual occlusion of the ipsilateral internal jugular vein during subclavian vein

cannulation, also known as "finger in the fossa" technique, can be applied for preventing malposition of catheter into internal jugular vein (22). In addition, appropriate catheter length is another important factor in terms of preventing catheter malposition. Inappropriate catheter length increases the risk of catheter malposition. Apart from these, ultrasound-guided access along with fluoroscopy-guided positioning has become widely considered to decrease the risk of this adverse event (23-26).

Since the available publications regarding this adverse event are in the form of isolated case reports or small case series which are cumbersome or time-consuming to access and do not provide pragmatic guidance or solutions to the problem, an universal consensus has not been established for the management of catheter malposition yet. Except in some exceptional cases, the recommendation in cases of central catheter malposition is to reposition, replace or remove the catheter as soon as it is practical (23,24). In all our cases, the malpositioned catheters were removed immediately after the detection of malposition.

While the surgeons usually prefer the blind-landmark approach without radiological guidance, the interventional radiologists use the radiological imaging modalities such as ultrasonography and fluoroscopy during CVC insertion. In many reports in recent years, it has been indicated that the radiological guidance during CVC insertion decreases the complications including catheter malposition (5,8,23-27). Nevertheless, despite this significant benefit of radiological approach, it has also several disadvantages as follows: Requirement of equipment and experienced staff, probable longer procedure time, radiation exposure, and additional cost of radiologic imaging. On the other hand, since we, the cardiovascular surgeons, are familiar with the percutaneous puncture technique and the anatomy of the chest and neck vasculature, and can detect possible complications and manage them promptly and accurately, we usually performed the blind-landmark technique in our procedures and but unfortunately more frequently encountered with this adverse event as compared with radiological guidance. Moreover, perhaps, another reason of this situation is that we have not sufficient experience to use the radiological approach. In our opinion, also based on our experiences, radiological guidance during CVC insertion should be preferred in all catheterization practices if possible.

Study Limitations

The main limitations of this study were its retrospective nature and single-centered design. Another important limitation of the study was the lack of the comparison between blind-landmark and radiological-guidance procedures. In addition, we could not provide sufficient data on the number of puncture, preference for puncture vessel and side because our work was a

retrospective study; thus, the aforementioned topics were could not be discussed in the light of practitioners' experiences.

Conclusion

It should be keep in mind that CVC insertion carries a substantial procedure-related catheter malposition risk even in the experienced hands. In spite of its some disadvantages, radiological-guided CVC insertion should be considered as first choice instead of the blind-landmark technique during CVC in order to minimize the occurrence of catheter malposition.

Ethics

Ethics Committee Approval: The study protocol was approved by Bolu Abant İzzet Baysal University Clinical Researches Ethics Committee (date: 19.12.2019; decision number: 2019/320).

Informed Consent: Before the procedure, all patients were informed about the intervention and their informed procedural consents were obtained.

Peer-reviewed: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: U.T.K.K., E.R.U., Concept: U.T.K.K., Design: U.T.K.K., Data Collection or Processing: U.T.K.K., E.R.U., Analysis or Interpretation: U.T.K.K., E.R.U., Literature Search: U.T.K.K., Writing: U.T.K.K., E.R.U.

Conflict of Interest: The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Financial Disclosure: The authors received no financial support for the research and/or authorship of this article.

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