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Complications Related to Insertion and Use of Central Venous Catheters (CVC)

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ABSTRACT

Introduction: Central Venous Catheters (CVC) are essential in everyday medical practice, especially in treating patients in intensive care units (ICU). The application of these catheters is accompanied with the risk of complications, such as the complications caused during the CVC insertion, infections at the location of the insertion, and complications during the use of the catheter, sepsis and other metastatic infections. **Patients and methods:** This study is a retrospective-prospective and it was implemented in the period 1st January 2011-31st December 2012. It included 108 examinees with CVC placed for more than 7 days. **Results:** The most common complications occurring in more than 2 attempts of CVC applications are: hearth arrhythmias in both groups in 12 cases, 7 in multi-lumen (12.72%) and 5 in mono-lumen ones (9.43%). Artery puncture occurs in both groups in 7 cases, 5 in multi-lumen (9.09%) and 2 in mono-lumen ones (3.77%). Hematoma occurred in both groups in 4 cases, 3 in multi-lumen CVCs (5.45%) and 1 in mono-lumen ones (1.88%). The most common complication in multi-lumen catheters was heart arrhythmia, in 20 cases (36.37%). The most common complications in mono-lumen CVCs was hearth arrhythmias, in 20 cases as extrasystoles and they were registered in 16 catheter insertions (30.18%).Out of total number of catheters of both groups, out of 108 catheters the complications during insertion occurred in 49 catheters (45.40%). The most common complications in both groups were heart arrhythmias, artery punctures and hematomas at the place of catheter insertion.

Key words: CVC, insertion, complications.

1. INTRODUCTION

Central Venous Catheters (CVC) are essential in everyday medical practice, especially in treating patients in intensive care units (ICU). The application of these catheters is accompanied with the risk of complications, such as the complications caused during the CVC insertion, infections at the location of the insertion, and complications during the use of the catheter, sepsis and other metastatic infections.

Patients that need having the CVC inserted are mostly treated at ICU, and those are the patients who are mostly vitally endangered, and it is very important to place the CVC successfully and without complications. CVCs are also used for parenteral nutrition, application of blood derivatives and antibiotics, chemotherapy central venous pressure measuring, at bone marrow transplantation, and other diagnostic procedures. More frequent CVC placement causes the increased number of complications related to the insertion and use of intravascular catheters.

Complications related to vascular approach can be divided in complications during the CVC insertion and complications during CVC use and maintenance. The most common complications occurring during CVC application are: hearth arrhythmias, artery puncture, improper position of CVC and hematomas at the place of catheter insertion. If the top of the catheter enters the right hearth chambers, it can cause hearth arrhythmias by touching the hearth structures. Urgent catheter insertion at vitally endangered patients carries a higher risk of complications of different kind, especially of catheter infection, so the recommendation is to replace such catheters (1).

Less common but more dangerous complications are superior vena cava wall perforation, left atrium wall perforation with cardiac tamponade, mediastinal hematoma, aorta perforation and hearth tamponade. The infections related to CVC application make 10-15% of nosocomial infections in ICU, and sepsis is the most important and the hardest by its complications (2).

The consequence of that is increased morbidity and mortality, and longer hospitalization which increases the treatment costs in general. Microorganisms colonizing the CVC often originate from the patients or the staff's skin, they come from infusion solutions, blood derivatives, but the source can also be a hematogenous dissemination from remote centers (3). Mono-lumen and multi-lumen CVCs are used in clinical practice.

2. PATIENTS AND METHODS

This study is a retrospective-prospective and it was implemented in the period 1st January 2011- 31st December 2012. It included 108 examinees with CVC placed for more than 7 days.

The examinees were divided in two groups: group A with 55 patients with inserted multi-lumen CVC (Certofix duo/trio. Braun, Germany) by well-established procedure into subclavian vein, and group B with 53 patients with mono-lumen catheters inserted into subclavian vein (Certofix mono-lumen, Braun, Germany).

Before the CVCs were inserted, the skin swabs had been taken from the catheter insertion place for microbiological examination. During the catheter insertion, the same measures of surgery field disinfection were performed: surgical cleaning with 2% chlorhexidine, the placement of sterile cover, and after the insertion of CVC, the insertion place was protected with thin, sterile self-adhesive gauze (4).

The following parameters were observed in both groups: the CVC insertion duration, colonization of the catheter and the occurrence of other complications related to the insertion and maintenance of CVC. Skin swabs were performed on day one, day seven and after the CVC removal. The top of the catheter (5 cm in length) was sent to the microbiological analysis after the CVC removal. For that purpose, the CVC top part of 5 cm in length was used, which was sent to the microbiological laboratory. The identification of the increased number of bacteria was performed according to standard microbiological procedures. After taking skin swaps around the CVC insertion place, the same was delivered into microbiological laboratory within 4 hours. The swap processing was performed according to standard microbiological procedures.

3. RESULTS

The examinees were divide in two groups. Group 1 with 55 multi-lumen patients and group 2 with 53 mono-lumen patients. The average age of multi-lumen patients was 58.7, and 61.2 in mono-lumen group.

		Group A n=55		Group B n=53	
		Number of CVC insertion attempts		Number of CVC insertion attempts	
		Two maximum	More than two	Two maximum	More than two
Pneumothorax	No	47	6	48	5
	Yes	0	2	0	0
Artery puncture	No	43	3	45	3
	Yes	4	5	3	2
Hearth Arrhythmias	No	34	1	37	0
	Yes	13	7	11	5
Hematoma	No	45	5	48	4
	Yes	2	3	0	1
Improper CVC position	No	44	7	48	5
	Yes	3	1	0	0

Table 1. The complications in insertion of both groups of catheters compared to the number of attempts of CVC insertion. (Group A –multilumen CVC, group B- monolumen CVC)

Bacteria	Both CVC groups	Multilumen	Monolumen
No	77 (71.29%)	34 (31.48%)	43 (39.81%)
KNS	11 (10.18%)	4 (3.70%)	7 (6.48%)
Staphyloccocus aureus	3 (2.77%)	2 (1.85%)	1 (0.92%)
Acinetobacter species	9 (8.33%)	8 (7.40%)	1 (0.92%)
Proteus mirabilis	2 (1.85%)	2 (1.85%)	0
Klebsiela pneumoniae	6 (5.55%)	6 (5.55%)	0
Enterococcus faecalis	7 (6.48%)	5 (4.62%)	2 (1.85%)
Pseudomonas aeruginos	0	0	0
Acinetobacter baumani	4 (3.70%)	4 (3.70%)	0
Stenotrophomonas maltophilia	1(0.92%)	1 (0.92%)	0
MRSA breed	0	0	0
ESBL breed	0	0	0
Total number in a group	108	55	53

Table 2- Total number of skin swap bacteria on day 7 for both CVC groups

The most common complications occurring at not more than 2 attempts of CVC application are: hearth arrhythmias in both groups in 24 cases, 13 at multi-lumen catheters (23.63%) and 11 at mono-lumen ones (20.75%).

Artery punctures in both groups in 7 cases, 4 in multi-lumen (7.27%) and 3 in mono-lumen ones (5.67%).

The most common complications occurring in more than 2 attempts of CVC applications are: hearth arrhythmias in both groups in 12 cases, 7 in multi-lumen (12.72%) and 5 in mono-lumen ones (9.43%). Artery puncture occurs in both groups in 7 cases, 5 in multi-lumen (9.09%) and 2 in mono-lumen ones (3.77%). Hematoma occurred in both groups in 4 cases, 3 in multi-lumen CVCs (5.45%) and 1 in mono-lumen ones (1.88%).

Pneumothorax was noted in 2 cases in multi-lumen CVCs and improper CVC position in 1 case in multi-lumen CVCs.

	Multilumen		Monolumen		Total
	Duration of CVC insertion <16 days	Duration of CVC insertion >16 days	Duration of CVC insertion <16 days	Duration of CVC insertion <16 days	
No	14	36	34	19	103
KNS	1	2	0	0	3
Staphyloccocus aureus	0	0	0	0	0
Acinetobacter species	0	1	0	0	1
MRSA breed	0	1	0	0	1
Total number in a group	15	40	34	19	108

Table 3. Bacteria hemoculture findings compared to the duration of CVC application in both groups, after CVC insertion.

Multi-lumen CVCs skin swap was positive on day 7 in 21 out of 55 cases (41.82%), and 10 out of 53 in mono-lumen CVCs (18.87%). (Table 2). There is a statistically important difference in higher bacteria occurrence within multi-lumen CVC group compared to mono-lumen CVCs group.

The difference in bacteria occurrence can be noted in hemoculture compared to the duration of CVC insertion in both types of the catheter. 16 days later there is a significant increase in positive hemoculture in both types of catheters. (Table 3)

The usage of catheter for more than 16 days leads to the increase of positive bacteriological cultures on the top of the CVC. With the longer duration of catheter insertion the presence of bacteria increases in both catheters (Table 4)

Group	Multilumen CVC		Monolumen CVC		Total
	Duration of CVC insertion <16 dana	Duration of CVC insertion >16 dana	Duration of CVC insertion <16 dana	Duration of CVC insertion>16 dana	
No bacteria	15	33	33	13	94
KNS	0	2	1	4	7
S.Aureus	0	3	0	0	3
Acin.Species	0	1	0	1	2
MRSA breed	0	1	0	0	1
Total number in a group	15	40	34	19	108

Table 4. Bacteriological findings of the top of CVC for both groups compared to the duration of the insertion

KNS is the most common isolated bacteria, and Acinetobacter species is also one of the isolated bacteria in all three samples which could be connected with the way of the bacteria entrance into the organism and the way they are spread and the consequences, i.e. the origin of the infection in patients related to catheter related infections. (Table 5)

The most common complication in multi-lumen catheters was heart arrhythmia, in 20 cases (36.37%). The most common complications in mono-lumen CVCs was hearth arrhythmias, in 20 cases as extrasystoles and they were registered in 16 catheter insertions (30.18%).

Out of total number of catheters of both groups, out of 108 catheters the complications during insertion occurred in 49 catheters (45.40%). The most common complications in both groups were heart arrhythmias, artery punctures and hematomas at the place of catheter insertion.

Some of the patients had two types of complications at the same time, but the leading complication was heart arrhythmias (Table 6)

4. DISCUSSION

The application of CVC is accompanied with the risk of complications, such as complications caused by CVC insertion and infections at the place of the catheter insertion, sepsis and other metastatic infections. The total number of complications during CVC insertion in both groups was 49 (42.37%). The number of complications can be reduced if the central vein puncture is performed under ultrasound control, which is becoming a standard (5).

	KNS	Acinetoba cter Species	Entero cocus faecalis	Staphylo cocus Aureus	MRSA	Klebsiela pneumoniae	Acinetobacter baumani	Proteus mirabilis
Skin swap	11	9	7	3	-	6	4	2
CVC top	7	2	1	3	1	-	-	-
Hemo-culture	3	1	-	-	1	-	-	-
Total	21	12	6	6	2	6	4	2

Table 5- the relation of skin swap, CVC top part and hemoculture with isolated bacteria

		Group	
		Multilumen CVC	Monolumen CVC
		n= 55	n= 53
Complications	No	23	36
	Yes	32	17
Hearth arrhythmias	No	35	37
	Yes	20	16
Artery puncture	No	46	48
	Yes	9	5
Hematoma	No	50	52
	Yes	5	1
Pneumothorax	No	53	53
	Yes	2	0
Improper CVC position	No	52	52
	Yes	3	1

Table 6. The relation of both CVC groups with complications

Heart arrhythmias were the most common complications during CVC insertion. In this study the heart arrhythmias occurred in 24 cases (22.23%), most often as supraventricular tachycardia and supraventricular extrasystoles, and ventricular extrasystoles were detected in 11 cases. It is pointed out that the frequency of atrial arrhythmia occurred in 41% of the patients and the ventricular ones in 25% of the patients (6). Arterial puncture is a very common complication that occurred in 12.54% of the cases (16.74% in multi-lumen catheters and 9.86% in mono-lumen ones). The subclavian artery puncture is pointed out in 7.88% of the cases in literature (7). It is believed that artery puncture is more common when placing the CVC in jugular vein (14.28%) compared to right infraclavicular approach in subclavian vein (4.17%) (8).

Potential artery puncture complications are not fatal, because the risk of cerebral thromboembolia and air embolism is at minimum. The bleeding can be controlled by compression at iatrogenic puncture of arteria jugularis, and the compression is less efficient at subclavian artery puncture. That is why the recommendation is that in coagulopathy patients, and in anticoagulant therapy patients, the advantage for CVC placement is on jugular vein.

CVC malposition was verified in 4 patients (2.75%) in both groups. Malposition occurred in 3 cases out of 55 catheters in multi-lumen catheters (5.46%) and in 1 case out of 53 mono-lumen catheters (1.87%). The malposition rate pointed out in literature is up to 14% (9). The malposition is more common in subclavian vein (3.42%) compared to jugular vein (1.48%) (10).

Catheter malposition can cause serious consequences including heart arrhythmias, cardiac tamponade and for-

mation of a thrombus. Malposition represents the most common reason for early CVC dysfunction.

In this study there were 95 cases with up to 2 attempts of CVC placement in both groups (87.96%). The number of unsuccessful attempts of CVC placement significantly increases the frequency of complications. The most common complications noticed in this study in up to 2 attempts of CVC placement were: heart arrhythmias in both groups in 24 cases, 13 in multi-lumen catheters (23.63%) and 11 in mono-lumen (20.75%). There were artery punctures in 7 cases both groups, 5 case in multi-lumen CVCs (9.09%) an 2 cases in mono-lumen CVCs (3.77%). There were 3 cases of malposition, all of them in multi-lumen CVCs and hematoma in 2 cases, both of them in multi-lumen CVCs, too. It can be noticed that the complications are more common in multi-lumen CVCs compared to mono-lumen ones. Hematoma and pneumothorax are more common in multi-lumen CVCs in more than two attempts of catheter applications. In traditional method, the complications occurred in 24% of the cases, and in ultrasound guided methods the complications occurred in 4.3% of cases (11)" The incidence of mechanical complications after 3 or more attempts of vein puncture was 6 times higher (12). Larger number of vein punctures increases the risk of later vein thrombosis and catheter connected sepsis (13).

The difference in the appearance of bacteria in hemoculture compared to the duration of cannulation in both catheter types. 16 days later, a more significant increase of positive hemoculture in both catheter types occurs. Cannulation longer than 16 days leads to an increase of positive bacteriological cultures on the top part of CVC. With longer cannulation the presence of bacteria in both catheter types increases. In shorter cannulation period up to 16 days, the bacteria were not isolated in multi-lumen CVCs, and they were isolated in 1 out of 34 cases (2.94%) in mono-lumen CVCs. Longer cannulation period of more than 16 days leads to increased bacterial infection appearance in both catheter types.

KNS was the most commonly isolated bacteria and Acinetobacter species is also one of the isolated bacteria in all three samples which could be connected with the way of the bacteria entrance into the organism, i.e. the origin of the infection in patients related to catheter related infections. Hemoculture findings proved catheter caused sepsis in 3 patients (2.77%), because other possibilities of its occurrence had been excluded. Sepsis usually occurs in immunocompromised patients, then in patients on long-term mechanical ventilation, after extensive surgeries and in patients who are on long-term corticosteroid therapy. The diagnosis of catheter caused sepsis is a subject of many disagreements. Definite catheter caused sepsis diagnosis requires earlier catheter removal with the top of the catheter culture as confirmation. Mani publications talk about the placement and maintenance of CVC, and a very small number about the importance of on-time removal (14). The need for CVC should be estimated every day and the catheter should be removed when there is no need for their use, in catheter infections and catheter thrombosis. While removing the catheter, life threatening complications can occur. These complications include: bleeding, embolism, infections and jammed catheter.

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5. CONCLUSION

We can conclude that the most common complications during CVC placement are heart arrhythmias and artery punctures, and the largest risk factor for catheter colonization is the use of CVC for more than 15 days. The measures for preventing the CVC complications are the use of aseptic conditions during CVC insertion, proper use and maintenance of CVC, removing the CVC as earlier as possible, 15 days before use if possible.

CONFLICT OF INTEREST: NONE DECLARED.

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