

Peripheral Arterial Catheter Related Infections in the Neurosurgical Intensive Care Unit

Jelena Radonić¹, Ljiljana Mihaljević², Radovan Radonić³, Dunja Rogić⁴, Ante Sekulić¹, Jadranka Katančić-Holjevac¹, Tamara Murselović¹ and Vasilije Stambolija¹

¹ University of Zagreb, University Hospital Center Zagreb, Clinic for Anesthesiology, Reanimatology and Intensive Care, Zagreb, Croatia

² University of Zagreb, University Hospital Center Zagreb, Department for Clinical and Molecular Microbiology, Zagreb, Croatia

³ University of Zagreb, University Hospital Center Zagreb, Division for Intensive Care Medicine, Zagreb, Croatia

⁴ University of Zagreb, University Hospital Center Zagreb, Clinical Institute for Laboratory Diagnostics, Zagreb, Croatia

ABSTRACT

*Intravascular device infections could be serious complications with significant contributable morbidity and mortality. The aim of this prospective clinical study is to demonstrate the infection rate related to peripheral arterial catheters and their clinical significance in neurosurgical intensive care unit (ICU) patients. After removal, all arterial catheter tips were cultivated by semiquantitative method and clinical data were collected. During a period of two years, 186 arterial catheters were placed in 105 neurosurgical ICU patients. In 6 cases (3.2%) infection was presumably related to the arterial catheter. The rate of such probable catheter related infections was found to be 5/1000 catheter days. The isolated microorganisms were: Methicillin resistant *Staphylococcus epidermidis* (MRSE) in 4 cases, *Corynebacterium* species and *Candida albicans* each in one case respectively. Thirteen cases (7.0%) were interpreted as contamination and one as colonization. An association was found between the presence of infection from different sources and significant bacterial growth on the catheter. Patients with positive catheter culture had a significantly longer ICU stay, more cumulative catheter days, and a higher mortality rate than those with sterile catheters. We can conclude that the rate of probable peripheral arterial catheter related infection is low. A higher mortality rate in patients who experienced probable catheter related infection does not seem to be a consequence of the aforementioned infection. A more suitable explanation would be that patients with nosocomial infections and higher mortality risk have prolonged ICU stays. There is an increased chance of developing a catheter related infection in those patients who have more cumulative catheter days.*

Key words: intravascular device, catheterization, peripheral artery, neurosurgery, intensive care unit, infection

Introduction

Intravascular devices are broadly used, particularly in ICU settings. Their use increases the risk for infectious complications with some attributable morbidity and mortality^{1,2}. The incidence of severe infections associated with peripheral vascular catheters, particularly arterial catheters, is usually lower than with central venous catheters. In the case of the latter, the average reported rate of associated bloodstream infection is 5.3 per 1000 catheter days compared to 2.9 per 1000 catheter days estimated for peripheral arterial catheters in the ICU^{3,4}. Reported attributable mortality of catheter related bloodstream infections ranges from 0–35%^{5–7}.

The main aim of this study is to estimate the risk and importance of infective complications associated with peripherally placed arterial catheters in neurosurgical ICU patients.

Patients and Methods

Study population

Patients with inserted peripheral arterial catheters, treated in neurosurgical ICU, predominantly admitted in ICU after neurosurgical operation. The study was approved by the UHC Zagreb Ethic Committee.

Peripheral arterial catheters

Peripheral arterial catheters were used in critically ill patients for continuous intraarterial blood pressure monitoring and to obtain samples for blood gas analysis.

Before catheter insertion, the skin was cleaned by 4% chlorhexidine gluconate and disinfected by 70% alcohol and 10% iodinated povidone. Under aseptic conditions, using sterile gloves, catheters (Arterial Cannula with FloSwitch, 1.1 x 45 mm, Becton-Dickinson) were percutaneously inserted into the radial, cubital, dorsalis pedis or femoral artery. Catheter and the attached disposable pressure transducer set (Gabarith™ PMSET 1 DT-XX, Becton-Dickinson) with blood sampling system (Safe-draw™, Becton-Dickinson) were flushed with 5000 units of heparin in 500 mL of normal saline solution. Transparent dressings were used (Tegaderm™, 3M Health Care). Catheters were routinely changed every 7 days together with the pressure transducer set. Occasionally, they were left in place longer than 7 days. If there was no further need for the catheter or clinical signs of possible catheter related infection developed, catheters were removed earlier. After removal, all catheter tips were analyzed using the semiquantitative technique of cultivation according to Maki⁸. Relevant patient data were recorded, including age, sex, diagnosis, Glasgow coma scale (GCS) at admission, type of surgical procedure, and presence of mechanical ventilation. Clinical signs of local or systemic infections were recorded, and the presence of infection from other sites was documented. Highest body temperature, leukocyte count, percentage of bands, and C-reactive protein (CRP) on the day of catheter removal were noted, as well as results of other microbiological tests and procedures important for a clinical understanding of a patient's infective state.

Definitions

Growth of 15 or more colony-forming units by semi-quantitative culture from a distal catheter segment was considered to be a significantly positive catheter culture. In the absence of accompanying clinical symptoms, this finding was interpreted as colonization. If clinical symptoms of infection were present in the absence of other sources of infection, a catheter related infection was presumed. Isolation of a significant number of the same microorganisms from the catheter tip and from blood cultures drawn from a peripheral vein accompanied by clinical symptoms was considered to be a catheter related bloodstream infection. When infection from a site other than the catheter was present in the patient, and it was unclear whether the symptoms of infection were catheter related, the infection was defined as a »probable catheter related infection«. When less than 15 colonies were cultivated from the catheter tip, the finding was interpreted as contamination. The catheter was considered sterile when no microorganisms grew upon being cultivated. Erythema, tenderness, induration, or purulence of the skin within 2 cm of the exit site of the catheter were criteria for infection of local site.

Statistical analysis

The Mann-Whitney test and Fisher Exact test were used for testing the statistically significant differences between variable values using the results of arterial catheter tip cultivation. P values of less than 0.05 were considered significant. In these tests, catheters categorized as contaminated were excluded. Because one patient can have more arterial catheters in sequence during one ICU stay, observations and tests were performed both in the population of catheters and in the population of patients.

Results

During the two year period, 186 peripheral arterial catheters were placed in 105 neurosurgical ICU patients. The patients' mean age was 54.7 years (SD±18.0). There were 60 (57.2%) male patients and 45 (42.8%) female. In 21 (20%) patients, neurosurgical procedures were performed due to cerebral artery aneurysms. In 46 (43.8%) patients, the reason for operation was an intracranial tumor. Of all the patients, 38 (38.1%) were trauma patients.

The average Glasgow Coma Scale (GCS) score at admission was 12.6. The mean length of ICU stay was 18.8 days (SD±15.1). Overall mortality was 7.6%.

TABLE 1
CLASSIFICATION OF CATHETERS ACCORDING TO THE CATHETER TIP CULTURE AND CLINICAL MANIFESTATIONS OF INFECTION

Categories of catheter related infection	Mircoorganisms isolated from the catheter tip
Sterile N=166	
Contamination N=13	6 MSSE 1 MRSE 1 <i>Acinetobacter species</i> 1 <i>Enterobacter species</i> 1 <i>Serratia</i> 1 <i>Pseudomonas aeruginosa</i> 1 <i>Streptococcus viridans</i> 1 <i>Staphylococcus aureus</i>
Colonization N=1	1 <i>Pseudomonas aeruginosa</i>
Probable catheter related infection N=6	3 MRSE 1 <i>Candida albicans</i> 1 <i>Acinetobacter Baumannii</i> 1 <i>Corynebacterium species</i>
Probable catheter related bloodstream infection (N=3)	(2 MRSE 1 <i>Candida albicans</i>)

MSSE – methicillin susceptible *Staphylococcus epidermidis*,
MRSE – methicillin resistant *Staphylococcus epidermidis*

TABLE 2
ANALYSIS OF CATEGORIC VARIABLES ACCORDING TO RESULTS OF ARTERIAL CATHETERS TIP CULTIVATION, CONTAMINATED CATHETERS WERE EXCLUDED

Variable	Sterile catheters N=166	Positive catheter tip culture; N=7	p
Sex (male:female)	100:66	6:1	0.251 (Fisher's exact test)
Placement of the catheter (arms:legs)	145:21	7:0	0.600 (Fisher's exact test)
Place of insertion (operation theatre:ICU)	57:109	2:5	1.000 (Fisher's exact test)
Mechanical ventilation (yes:no)	67:99	4:3	0.443 (Fisher's exact test)
Other concomitant infection in the patient (yes:no)	60:106	6:1	0.013* (Fisher's exact test)
Patients age (median, range)	63.0 (6–89)	66.0 (10–71)	0.978 (Mann Whitney test)
GCS at admission (median, range)	14.0 (3–15)	12.0 (4–15)	0.356 (Mann Whitney test)
Temperature (°C) (median, range)	37.5 (36–40)	38.0 (37–39)	0.201 (Mann Whitney test)
Leukocyte count (median, range)	11.0 (3–28)	10.0 (7–15)	0.620 (Mann Whitney test)
Bands (%) (median, range)	1.0 (0–20)	5.0 (0–15)	0.285 (Mann Whitney test)
C-reactive protein (median, range)	69.5 (1–407)	54.0 (11–160)	0.748 (Mann Whitney test)
Catheter days (median, range)	7.0 (1–14)	6.0 (6–8)	0.789 (Mann Whitney test)

ICU – intensive care unit, * $p < 0.05$, GCS – Glasgow coma scale, Temperature – the highest body temperature on the day of catheter removal

TABLE 3
ANALYSIS OF VARIABLES IN NEUROSURGICAL ICU PATIENTS ACCORDING TO RESULTS OF CATHETER TIP CULTIVATION, PATIENTS WITH CONTAMINATED CATHETERS WERE EXCLUDED

Variable	Patients with sterile catheters N=87		Patients with positive catheter cultures N=7		Mann-Whitney test
	Median	Range	Median	Range	p
Cumulative catheter days	7	(2–35)	19	(7–58)	0.018*
Length of ICU stay	14	(2–60)	27	(12–65)	0.017*

* $p < 0.05$

The mean length of use of a single catheter was 6.4 days ($SD \pm 2.3$).

Classification of catheters according to catheter related infection and isolated microorganisms is demonstrated in a table (Table 1). In 7 cases (3.8 %), a positive catheter tip culture was found. In 6 cases (3.2%), arterial catheter related infection was presumed; thus, probable catheter related infection rate was 5/1000 catheter days. In half of cases categorised as probable catheter related infection the same microorganisms were isolated both from the catheter tip and from blood cultures, so catheter related bloodstream infection could be supposed. In one case of positive catheter tip culture, no clinical signs of infection were present in the patient at the moment of catheter removal, thus the finding was interpreted as colonization. 13 cases (7.0%) were interpreted as contamination. No signs of local catheter related infection were documented.

In 107 (57.5%) cases, there were no signs of infection in patients during the period when catheter was in place. Urinary infection was detected in 36 (19.3%) cases, respiratory infection in 23 (12.3%) cases, infection of the central nervous system in 11 (5.9%) cases, and other infec-

tions were detected in 9 (5.4%) cases. Mechanical ventilation was used in 77 (41.4%) cases.

In all but one case of a significantly positive catheter culture, another concurrent infection from a different source was diagnosed, which was significantly different when no microorganisms were cultivated from catheter tips (Table 2). Values of other variables did not show significant differences, but it should be noted that a small number of cases with positive catheter tip cultures reduces the power of statistical tests. Out of a total of 186 peripheral arterial catheters, 132 (71.0%) were placed in a radial artery, 31 (16.7%) were placed in a brachial artery, 22 (11.8%) in a dorsalis pedis artery, and 1 (0.5%) in a femoral artery. The number of catheters inserted in the operating room was 66 (35.5%), while 120 (64.5%) catheters were inserted in the ICU. Patients with positive catheter cultures had a significantly longer length of ICU stay and more cumulative catheter days (Table 3). Of 7 patients with a positive catheter tip culture, 2 patients died. This was a significantly higher mortality rate as tested by Fisher's Exact test ($p = 0.046$) than was observed in patients with negative catheter tip cultures in whom the mortality rate was 5.8%. Clinical analysis of

patients' data in patients with probable catheter related infection and lethal outcome has shown that the reason for prolonged ICU stay and death was severe cerebral impairment due to cerebral contusions with haemorrhages and cerebral edema. The patients were comatose, developed multiple organ failure, and other nosocomial infections independent of arterial cannula colonization. In one of these patients, *Staphylococcus epidermidis* was isolated from one of three arterial catheters, while in the other patient, *Candida albicans* was isolated in one of nine arterial catheters used during the prolonged ICU stay.

Discussion

Previous studies have shown that peripheral arterial catheters might be associated with a lower risk of catheter related infection than short peripheral and central venous catheters left in place for a comparable length of time⁹. This could be explained by the fact that arterial catheters are exposed to higher vascular pressures¹⁰.

In this study, the rate of probable arterial catheter related infection was 3.2% i.e. 5/1000 catheter days, which is comparable with other studies^{11–18}.

Though it seems simple, the diagnosis of catheter related infection in some cases can be difficult and uncertain. By the definition of catheter related infection, any other source of infection in patient should be absent³. However, in the population of ICU patients, infections are common. When the catheter tip is significantly colonized and the patient has another source of infection, it is difficult to conclude whether the clinical signs of infection are related to catheter colonization, the other infection, or both. Thus, in the case of a significant number of bacterial colonies having been isolated from the catheter tip in a patient with clinical symptoms of infection but with concurrent infection from another source, the catheter related infection can only be presumed. For this reason, it is unclear what proportion of catheters with significant bacterial colonization has the potential to cause an inflammatory reaction in the host.

On the other hand, symptoms of infection from sources other than the catheter can mask catheter related infection which could significantly influence morbidity and mortality if unrecognized and untreated¹⁹.

We have classified as »probable catheter related infections« those cases in which positive catheter tip cultures were accompanied by clinical signs of infection and concurrent infection from a different source. It is not clear how such cases are usually classified in literature.

MRSE was the most frequently isolated pathogen, which supports the hypothesis that bacterial migration from the skin to the intravascular segment of the catheter plays an important role in the pathogenesis of catheter related infection⁸. Slime production and adherence of coagulase negative *Staphylococci* to the catheter could be the other explanation^{20–22}. Coagulase negative *Staphylococci* are of minor clinical importance compared to other, more virulent bacteria in an immunocompetent host.

In literature, factors shown to predispose patients with peripheral arterial catheters to catheter-related infection are: inflammation at the catheter insertion site, catheterization lasting more than 4 days, or catheter insertion by cutdown^{23,24}.

Fufaro and his team found a correlation between the duration of catheterization and risk of catheter colonization. The risk remained constant for 2 to 20 days at 6.2%. No colonization of catheters left in place for 48 hours or less was documented²⁵. Such a relation could not be demonstrated in our study due to a small number of microbiologically positive catheters.

According to literature, catheters inserted in lower extremities do not pose a greater risk of infection than do peripheral arterial catheters inserted in upper extremities or brachial areas, which is in accordance with our results²⁶.

In this study, the presence of infection in patients, prolonged ICU stay, more cumulative catheter days, and a higher mortality rate were found to be associated with significant catheter tip colonization. Because microorganisms found on the catheter were different from the causative agents of infection from other sites, a hematogenous route of catheter colonization is not a good explanation for the associated presence of arterial catheter colonization and a concurrent infection. Additionally, it cannot be concluded that catheter related infections significantly influence morbidity and mortality. A better explanation is that the presence of infection from any source could result in a prolonged ICU stay associated with more cumulative catheter days when chances for catheter colonization and development of catheter related infections increase¹⁴.

More difficult cases with a prolonged ICU stay have a higher mortality rate. The contributable morbidity remains unclear, but after clinical analysis of each case, it does not seem important. Association of catheter colonization with more cumulative catheter days supports the opinion that the risk for the development of catheter related infection is linear.

Conclusions

The rate of peripheral arterial catheter related infection is low. Infection from other sources, prolonged ICU stay, and more cumulative catheter days are found to be associated with the development of catheter related infection. Even possible catheter related infections are associated with higher ICU mortality; they should not be interpreted as significant contributing risk factors. A more probable interpretation of this observation should be that infections from another site are associated with a higher mortality rate as well as with a prolonged ICU stay and more cumulative catheter days. This in turn increases the chance for development of catheter related infection.

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J. Radonić

University of Zagreb, University Hospital Center Zagreb, Clinic for Anesthesiology, Reanimatology and Intensive Care, Department of Neurosurgery, Kišpatičeva 12, 10000 Zagreb, Croatia
e-mail: jelenaradonic@yahoo.com

INFEKCIJE POVEZANE S UPOTREBOM PERIFERNIH ARTERIJSKIH KATETERA U NEUROKIRURŠKOJ INTENZIVNOJ JEDINICI

SAŽETAK

Infekcije intravaskularnih katetera mogu značajno doprinjeti morbiditetu i mortalitetu. Cilj ove prospektivne kliničke studije je uvidjeti učestalost infektivnih komplikacija povezanih s upotrebom perifernih arterijskih katetera i njihovu kliničku značajnost u populaciji bolesnika liječenih u neurokirurškoj intenzivnoj jedinici. Nakon vađenja katetera vršak svih katetera je kultiviran semikvantitativnom metodom i prikupljeni su relevantni klinički podaci. U vremenskom periodu od 2 godine 186 perifernih arterijskih katetera postavljeno je u 105 bolesnika liječenih u neurokirurškoj intenzivnoj jedinici. U 6 bolesnika (3.2%) pretpostavljena je vjerojatna infekcija povezana s upotrebom arterijskog katetera. Učestalost vjerojatne infekcije povezane s upotrebom arterijskih katetera iznosi 5/1000 kateter dana. Izolirani mikroorganizmi bili su: *MRSE* u 4 slučaja, *Corynebacterium species* i *Candida albicans* u po jednom slučaju. 13 slučajeva (7.0%) interpretirano je kao kontaminacija, a jedan kao kolonizacija katetera. Nađena je povezanost između prisustva druge infekcije u bolesnika i prisustva značajnog broja mikroorganizama na vršku katetera. Bolesnici s pozitivnim mikrobiološkim nalazom kultivacije vrška katetera imali su dulji boravak u intenzivnoj jedinici, više ukupnih dana s arterijskim kateterom i višu smrtnost od onih u kojih je vršak katetera bio sterilan. Možemo zaključiti da je učestalost infekcija povezanih s upotrebom arterijskih katetera niska. Viša smrtnost u bolesnika u kojih je pretpostavljena infekcija povezana s upotrebom arterijskih katetera ne čini se da je i posljedica infekcije povezane s upotrebom katetera. Bolje objašnjenje je u tome da teži bolesnici, lošije prognoze, s drugim infekcijama koje kompliciraju klinički tijek, dulje borave u jedinici intenzivne skrbi, imaju više ukupnih dana s arterijskim kateterom i stoga veće izgleda za razvoj infekcije povezane s upotrebom arterijskog katetera.