Intravascular catheter colonization and related bloodstream infection in the heart surgery intensive care unit

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ABSTRACT

الأهداف: من أجل دراسة الحوادث الناجمة من استخدام القسطرة، والتهاب القسطرة، وعوامل الخطر لديها. ومقارنة هذه البيانات مع الدراسات الأخرى.

الطريقة: منذ عام 2006م، كان لدينا برنامج للتركيب ولرعاية جميع القسطرات، والتي يتم استعمالها في وحدة العناية المركزة لجراحة القلب (SICU) في جامعة تبريز للعلوم الطبية – إيران. قمنا بدراسة 183 قسطرة لـ150 مريضاً فيما يتعلق ببيانات التركيب، وخصائص القسطرة، ووقت القسطرة، والزراعات الميكروبية. تم تركيب هذه القسطرات (<48) ساعة على 16 شهراً. تم تحليل عوامل الخطر بواسطة تحليل المتغيرات المتعددة.

النتائج: شمل التحليل 115 قسطرة وريدية مركزية (CVCs)، و65 قسطرة شريانية (ACs)، وتركيب 3 قسطرات للشريان الرئوي لـ150 مريضاً. بلغ متوسط الوقت للقسطرة 4 أيام، كما بلغت نسبة حدوث مزرعة إيجابية 9.8%، وعشر معزولات مجهرية حية دقيقة من 18 حالة قسطرة مستعمرة. ثلاثة عشر عصيات باسيلي سالبة الجرام وأربعة مكورات موجبة الجرام، وتم العزل لعام واحد. من تحليل المتغيرات المتعددة، (6>) أيام كانت المتغيرات المصاحبة للقسطرة وموضع التركيب مع زيادة ملحوظة في عوامل الخطورة للاستعمار.

خاتمة: كانت عصيات باسيلي سالبة الجرام والمكورات موجبة الجرام من أكثر مستعمرات الأحياء الدقيقة المجهرية (CVC) و (AC) الشائعة في القسطرات الوريدية المركزية والقسطرات الشريانية لدى مرضى وحدة العناية المركزة لجراحة القلب (SICU). كانت فترة القسطرة وموضع تركيب القسطرة عوامل الخطر للالتهاب ذي الصلة بالقسطرة.

Objective: To study the incidence of catheter tip colonization, catheter-related infections, their risk factors, and to compare these data with other studies.

Methods: Since 2006, we have had a through program for the insertion and care of all catheters used at cardiac surgical intensive care unit (SICU), Tabriz University of Medical Sciences, Tabriz, Iran, between May 15, 2006 and September 15, 2007. We studied prospectively 183 catheters in 150 patients in relation to insertion data and catheter characteristics, catheterization time and microbiological cultures. These catheters were in place for >48 hours over a 16 months period. Risk factors were analyzed by multivariate analysis.

Results: The analysis included 115 central venous catheter (CVCs), 65 arterial catheters (ACs), and 3 pulmonary artery catheters (PACs) inserted in 150 patients. The median time of catheter placement was 4 days. The incidence of positive tip culture was 9.8% and 10 microorganism isolated from 18 colonized catheters. Thirteen Gram-negative bacilli, 4 Gram-positive cocci, and one yeast were isolated. From multivariant analysis, >6 days of catheterization, and insertion site were the variables associated with significantly increased risk of catheter colonization.

Conclusion: Gram-negative bacilli and Gram-positive cocci are the most common microorganisms colonizing CVC and AC from cardiac SICU patients. Duration of catheterization and catheter insertion site were independent risk factors of catheter related infection.

Arterial catheters (ACs) are frequently used for continuous hemodynamic monitoring and drawing blood samples from cardiac surgery patients. Although mechanical complications of ACs was reported in most studies, limited researchers have investigated AC-related infections by using quantitative culture techniques.[1-4] Pulmonary artery catheters (PACs) were inserted in severely ill patients and catheter colonization and catheter-related bacteremia can be resulted from the use of PACs. Insertion of a central venous catheter (CVC) is a common procedure and each catheter placed into a central vein may induce some morbidity: complications are mainly mechanical,[5] thrombotic,[6] and infectious.[7] Among those, catheter-related bloodstream infection (CRBSI) is the most important complication and the second cause of nosocomial infection in the intensive care unit (ICU)[8-10] and considerably increases costs of hospitalization.[11-14] Up to 90% of CRBSI originate from CVC.[15] Bacteremia occurred in 5% of patients with ≥48 hours ICU stay in a case-control study; in 1.5% of them, there was a confirmed CRBSI.[14] Diagnosis of intravascular catheter related infections using clinical signs are usually difficult. Consequently, culture of the catheter tip is required to recognize its infection. Several authors analyzed intravascular colonization and infection in medical or surgical intensive care unit (SICU) patients.[16-19] To our knowledge, there is no large cohort study of the epidemiology and analysis of risk factors associated with intravascular colonization infection specifically conducted in a cardiac SICU. In this article, we reported the finding of a 16-month prospective study in a cardiac SICU and assess the incidence and etiology of colonization and infection of intravascular catheter in place for >48 hours. We also reported the influence of some variables on the risk developing intravascular catheter colonization and infection using the univariant and multi-variant statistical analysis. Our purpose was to study the incidence of catheter tip colonization, CRI, their risk factors, and to compare these data with other studies.

Methods. *Patients and catheters.* This prospective study was performed in SICU, Tabriz University of Medical Sciences, Tabriz, Iran, between May 15, 2006 and September 15, 2007. The study population was consisted of all heart surgery patients spending >48 hours in SICU over a-16-month period. Approved by Regional Medical Research Ethic Committee prior to the commencement of the study, and informed consent was obtained. The nurse-to-patients ratio in this unit was 1:2. Patients enter the ICU directly from the operating room with several intravascular catheters in place. These includes an arterial catheter, a pulmonary artery flotation catheter, a central catheter,

and a peripheral catheter. All catheters are inserted by experienced anesthesiologists in the operating room. No catheters coated with antimicrobial agents or heparin were used. All patients underwent placement of polyurethane latex free double lumen CVCs (from Arrow International, Inc, USA) and ACs polyurethane latex free catheters (Arrow International, Inc, USA or Angiocath). 7-Fr pulmonary artery catheters were inserted, natural rubber latex catheters (Arrow International, Inc, 2400 Bemile Road, Reading P.A, 19605 USA) and allowed the continuous monitoring of pulmonary arterial pressures and cardiac output with mixed venous oxygen saturation. The internal jugular vein was the preferred site of PAC insertion, despite its association with a higher risk of infection compared with the subclavian site.[20] Central venous catheters are used to deliver medications and to measure venous pressure. At the time of catheter placement, a 10% povidone-iodine solution was applied to the insertion site by vigorous scrubbing; the anesthesiologists routinely wore a cap, mask, and sterile gloves. The insertion site was covered with sterile drape. After wiping any excess solution with sterile gauze, the catheter was inserted and dressed with sterile gauze. Occlusive dressings were routinely changed every 48 hours, cleaned the skin site with iodine solution, and stopcocks, connect-tubes, infusion-tubes, and heparinized normal saline solution were changed every 4-5 days. Antibiotic prophylaxis consists of cefazolin or vancomycin (hypersensitivity to [beta]-lactam antibiotics) and continues up to removal of chest tubes. Intravascular catheters were removed when homodynamic monitoring was no longer needed or when catheter-related infection was suspected. The clinical status of the patients assessed in multiple times daily by on site attending and fellows. The insertion sites were examined as a routine part.

Microbiology. After skin insertion site cleaning with a 10% povidone-iodine solution, catheters were withdrawn aseptically, and 2-3 cm segment of catheter tips were sectioned with sterile scissors and dropped into sterile culture containers. All catheter tips were sent to the Microbiology Laboratory for quantitative culture. Catheters were cultured quantitatively by using the technique described by Brun-Buisson et al.[21] Briefly, one ml of sterile saline containing the distal tip was vigorously vortexes for one minute after which an aliquot of 0.1 ml of the suspension was plated onto a blood agar Petri dish. After 24 and 48 hours of cultures, colonies were counted and identified with standard methods and criteria. Results are reported as colony-forming units per milliliter (cfu/ml), after correction for the 1:10 dilution. For all patients, peripheral blood sample were collected at the time of catheter removal and for patients exhibiting clinical signs of infection (fever, chill, hypotension, leukocytosis, leukopenia),

peripheral blood samples were collected at the time of catheter removal and subsequently cultured. A total of 3 blood cultures were obtained. Standard microbiological methods were used to identify the colonizing/infecting organisms. Intravascular catheter colonization was defined as colonization of the catheters. Significant catheter colonization was defined as a quantitative microorganism at a concentration of ≥10³ cfu/ml. Catheter contaminations were defined as a quantitative culture of a catheter tip showing one microorganism at a concentration of <10³ cfu/ml. Intravascular catheter related bacteremia was defined as isolation of the same organism from peripheral blood and intravascular catheter culture (2 blood culture were needed for coagulase-negative *staphylococci*), with the absence of other identifiable source of bacteremia. The period between June 22 and September 22 were considered as summer.

Statistical analysis. The outcome variable of interest was intravascular catheter colonization. To identify independent risk factors predictive of catheter colonization 9 dichotomous variables from data obtained at the time of the culture removal were subject to univariate analysis: age (>65 years), gender, type of cardiac surgery, type of procedure (single versus multiple), duration of extracorporeal circulation (>120 minutes), duration of mechanical ventilation (>48 hours), duration of inotrope receiving, period of insertion (summer versus other), insertion site duration of catheter placement (>48 hours), presence of subsequent infection, and curative antimicrobial therapy.

Length of ICU stay, and ICU mortality were also recorded. Positive quantitative culture (PQC) of intravascular catheter tips and intravascular catheter related bacteremia rates were expressed in terms of cumulative incidences and incidence densities. Cumulative incidence was expressed as percentage and incidence density as PQCs per 1000 catheter days. Variables were compared by 2 sample t test, chi-square test, or Fisher's exact test, when necessary. Two-tailed *p* value of <0.05 were considered to indicate statistical significance. Statistical analyses were performed using the Statistical Package Social Science (SPSS) version 11.5 for windows (SPSS, Chicago, IL).

Results. Over the 16-month study period, 2145 patients underwent cardiovascular surgery. Of these 150 had a CVC, AC, or PAC in place for >48 hours, and all catheters were inserted in the operating room and removed during ICU stay. Thus, the study involved 183 catheters (115 CVCs, 65 ACs, and 3 PACs) inserted in 150 patients men and 52 (34.7%) women (gender ratio, 1:88) with a mean ± SD age of 44.39 ± 23.22 years (median, 52 years) and their characteristics were

summarized in **Table 1**. The median time of catheter placement was 4 days. The number of cumulative days of catheter use was 891, and number of catheter-days was 3-16. The characteristics of the catheters used are provided in **Table 2**. On withdrawal of the catheters, 18 (16 CVCs, 2 ACs) of 183 tips (9.8%) were culture positive. Results of catheter cultures are shown in table 3. Central venous catheter-PQC was observed in 16 (13.9%) of 115 cases. There was a significant difference

Table 1 - Characteristics of 150 patients and 183 catheter studied.

Characteristic	n (%)
Age (years) (mean ± SD)	44.39 ± 23.22
Male	98 (65.3)
Type of cardiac surgery	
Coronary artery bypass grafting	76 (50.7)
Congenital heart disease	35 (23.3)
Valve procedure	24 (16)
other	15 (10)
Type of procedure	
Single	135 (90)
Multiple	7 (4.7)
Duration of extracorporeal circulation (mins) (mean ± SD)	122.58 ± 55.07
Period of insertion	
Summer	68 (45.3)
Other	82 (54.7)
Duration of catheterization (days) (mean ± SD)	4.87 ± 2.62

Table 2 - Characteristics of the catheters inserted over the study period.

Insertion site	No. of catheter (%)	No. of duration (days) Mean ± SD	Cumulative incidence: PQC-catheter/No. of catheters (%)
Central vein catheter			
Any site	115 (62.8)	4.98 ± 2.51	16/115 (13.9)
Jugular	103 (56.3)	4.51 ± 2.03	12/103 (11.6)
Subclavian	10 (5.5)	8.80 ± 2.78	4/10 (40)
Femoral	2 (1.1)	10.00 ± 2.82	-
Arterial catheter			
Any site	65 (35.5)	4.69 ± 2.86	2/65 (3.1)
Radial	45 (24.6)	4.00 ± 1.79	1/45 (2.2)
Femoral	15 (8.2)	6.80 ± 4.37	1/15 (6.6)
Brachial	5 (2.7)	4.60 ± 2.51	-
Pulmonary artery catheter			
Any site	3 (1.6)	4.33 ± 2.30	-
Femoral	1 (0.5)	7.00 ± 0.00	-
Jugular	2 (1.1)	2.00 ± 0.00	-
PQC - positive quantitative culture			

Table 3 - Incidence of cultured microorganisms

Microorganism	No. of CVC cultures	No. of AC cultures
Gram-negative bacilli		
Escherichia coli	4	1
Pseudomonas areroginosa	3	
Proteus volgaris	2	
Acinetobacter	1	
Streptobacillus moniliformis	1	
Nonfermentative bacillus		1
Gram-positive cocci		
Staphylococcus epidermidis	2	
Staphylococcus aureus	1	
Staphylococcus coagulase negative	1	
Yeast		
Candida species	1	

CVC - central venous catheter; AC - arterial catheter

in the mean duration of CVC placement with or without PQC (6.92 ± 2.96 days [median, 6 days]) versus 4.71 ± 2.33 [median, 4 day]; *p*=0.003). The rate of PQC was greater with subclavian vein catheters than with those placed via the internal jugular route (*p*=0.034). The 65 AC were mostly in the radial site (70.31%). The mean ± SD duration of AC placement was 4.69 ± 2.86 days (median, 4 days). Arterial catheters-PQC was observed in 2 (3.1%) of 65 cases, with no significant difference according to the insertion site (*p*=0.441). There was no difference in the mean duration of AC placement with or without PQC (2.00 ± 1.41 days versus 1.52 ± 0.84 days; *p*=0.439). Globally, cultures were negative in catheters (90.2%) with mean duration of catheterization of 4.65 ± 2.48 days. Colonization was found in 18 catheters (9.8%) with mean duration of catheterization of 6.89 ± 3.08 days. The incidence of colonization was 139 episodes per 1000 catheterization days.

Of 150 patients studied, all patients received peripheral blood culture at the time of catheter withdrawal and blood culture was negative in all them. Ten microorganisms were isolated from the 18 colonized catheters (**Table 3**). Thirteen (72.2%) Gram-negative bacilli (GNB), 4 (22.2%) Gram-positive cocci (GPC) and 1 (5.5%) yeast were isolated. The most commonly organism was *Escherichia coli* (*E. coli*) (27.7%) followed by *Pseudomonas aeruginosa* (16.6%) and *Staphylococcus epidermidis* (11%). Of the 150 patients, 23 (15.3%) had invasive mechanical ventilation >48 hours and the mean ± SD length of ICU stay was 8.61 ± 14.25 days (median=4; range 2-131). 88 (58.7%) patients required vasopressor support after operation and the ICU mortality rate was 5 (3.3%).

Discussion. In this prospective study of 183 catheters inserted in 150 cardiovascular surgery patients, the incidence of catheter colonization was 9.8% (n=139 episodes per 1000 catheter-days). Our finding is consistent with the results of catheter colonization and catheter-related bacteremia in various critically ill patients ranging from 5.9-29.1% and from 0-4.6%.[22,23] Catheter colonization was caused by GNB in 72.2%, GPC in 22.2% and *Candida Albicans* in 5.5% (**Table 3**). This particularly high rate of GNB is in agreement with data obtained from 2 prospective studies, GNB were observed in >65% of colonized catheters.[24-26] Although our finding usually differed from those found and GPC were more common than GNB, and among the GPC, Coagulase-negative *staphylococci* were predominant.[18,27] In comparison with other studies, we found a high proportion of *E. coli* species with regard of colonization.[19,28-32] This result must be evaluated further. The present high rate of catheter colonization caused by GNB also could be linked to an excessively long duration of antibiotic prophylaxis (>2 days). A lengthy duration of antibiothic therapy could, in hospitalized patients, alter the balance of the normal endogenouse flora.[33] Antibiotic prophylaxis with cefazolin was associated with increased levels of postoperative colonization for *Enterobacter* species in cardiac surgery patients.[26] This could be the causes of cefazolin-resistant GNB, and particularly *E. coli*, and *Pseudomonas aeroginosa* found in patients. Risk factor multivariate analysis demonstrated that duration of catheterization >6 days and central venous catheters were associated with a significantly increased risk of catheter colonization. A positive correlation between duration of central venous catheterization and increased infection risk has been demonstrated previously.[34] In our study, mean duration of catheterization was 4.87 ± 2.62 days (139 per 1000 days) (**Table 1**) with a peak of 6.89 ± 3.08 days in the colonized group. This study delineated this risk specifically in cardiac patients' population. In this study, CVC-PQC was observed in 13.91% and AC-PQC in 3.07%. Unlike most authors, we observed difference in the frequency of PQC between CVCs and ACs.[18] We proved a statistically significant difference in infection rate among the insertion site. Finally, this study could be limited by uncertainty on the potential effect of it un-blinded design. Nevertheless, our concerted efforts to standardized intensive care, particularly catheter maintenance in the cardiac SICU, and use of vigorous criteria to define colonization and infection probably minimized bias attributable to differences in the management of studied patients.

In conclusion, GNB and GPC are the most common microorganisms colonizing CVC and AC from cardiac SICU patients. Duration of catheterization and catheter insertion site were independent risk factors of catheter related infection. The increasing resistance of bacterial to antimicrobial agent is the major problem in spite of restricted policy of using antimicrobial agent in cardiac SICU.

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