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Complications of central venous catheter cannulation in tertiary care hospital ICU, a 2 years retrospective, observational study

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Key points

Various complications can arise during the management of central venous catheter in adult and pediatric patients.The study of incidence of complications allows us for better evaluation and to minimize the risk associated with central venous catheter cannulations.

Abstract

Background. Central venous catheter (CVC) cannulations are associated with complications like arterial puncture, hematoma, pneumothorax, thrombosis and sepsis. These complications may be particularly dangerous in paediatric patients.

Aim. To study the incidence of complications like arterial puncture, hematoma, pneumothorax, thrombosis and sepsis of CVC cannulations from three different routes, internal jugular vein (IJV), subclavian vein (SV) and femoral vein (FV) in critically ill patients were studied.

Setting & Design Medical and surgical intensive care unit of a tertiary care hospital. A 2 years retrospective, observational study.

Materials and Methods This was a retrospective review of 542 CVC cannulations done on adult and paediatric patients admitted in ICU including pre and postoperative patients over 2 years period from July 2011 to June 2013.

Results. Total of 542 CVC cannulations were studied, out of which 48 patients had arterial punctures, 17 had haematomas, 7 had pneumothorax, 13 developed thrombosis and 23 Sepsis. Incidence of arterial punctures (16.6%), hematoma (4.4%) and pneumothorax (2.2%) were more with SV cannulations. Sepsis (13.3%) and thrombosis (8.8%) were more with FV cannulations.

Conclusions. Internal jugular venous access is associated with low rate of severe complications as compared with subclavian and femoral vein access.

Keywords: central venous catheter cannulation; complications; intensive care unit.

Introduction

Central venous catheters (CVC) are an integral part of patients care in the intensive care unit (ICU). The indications for CVC are monitoring of the haemodynamic state of the patient, pulmonary artery catheterization, emergency transvenous pacemaker, hemodialysis, severe hypovolaemia with difficult

peripheral venous access, total parenteral nutrition and irritant medications. However, complications associated with CVC occur in nearly 15% of patients, mainly mechanical complications (5–19%), infectious complications (5–26%) and thrombotic complications (2–26%).[1,5] These complications results in prolong stay in ICU and increases the cost of treatment, increase in morbidity and mortality.[2] Despite the advent of ultrasound-guided vascular cannulation, which has reduced the incidence of complications drastically, many hospitals in India andother developing countries still rely on the landmark based technique for cannulation, which has a reported success rate of 75–99%.[3] However, there are very little data available from Indian ICUs on therate of complications associated with CVC. Hence, we undertook a retrospective study to find out the incidence of complications like arterial punctures, hematoma, pneumothorax, thrombosis and sepsis of CVC inserted by the landmark based technique in adult and paediatric patients in ICUs.

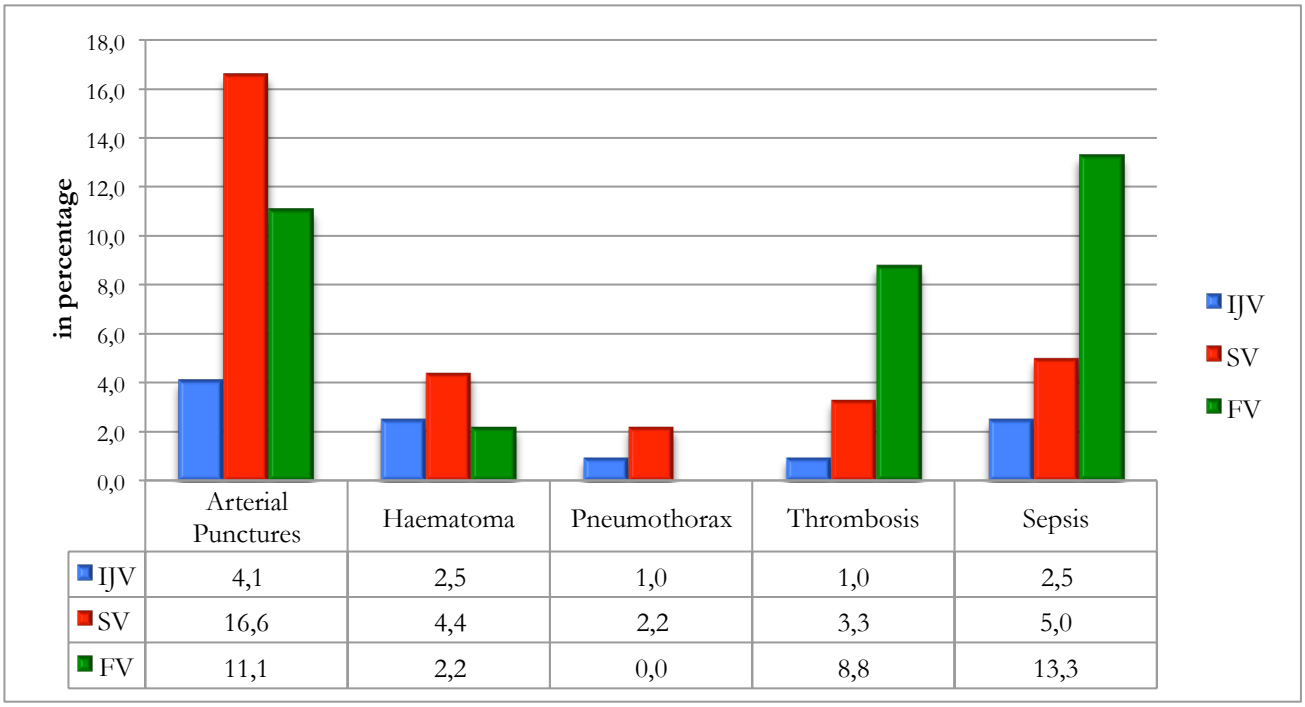
Material and Methods

After approval from the hospital ethical committee, we retrospectively analyzed all landmark-based CVC cannulations using Seldinger technique performed during July 2011 to June 2013 in 542 patients in our hospital. CVC cannulations from three different routes i.e. IJV, SV and femoral vein in critically ill patients were analyzed. We recorded baseline data for each patient and APACHE II score were noted. CVC were inserted either by an ICU consultant or by a senior registrar, who had minimum experience of at least 25 CVC insertions, under supervision. Puncture site was chosen according to clinical status of the patient. CVC in operation theater, casualty and by inexperienced residents were excluded from study. Data, such as indication, complications and site of CVC cannulation were recorded. During cannulation if red bright colored blood gushed into the syringe, arterial puncture was suspected. Needle was withdrawn from the insertion site, pressure was applied for 5 minutes and the site was abandoned for cannulation. If patient developed unexplained tachypnea and/or tachycardia during cannulation, procedure was abandoned and chest radiograph was taken to check for pneumothorax. If patient had symptoms of catheter related blood stream infection (CRBSI) and/or local infection blood culture/ site swab was sent for culture and sensitivity. In paediatric patients the procedure was always performed under sedation.

Catheter-associated infections were defined as follows [4]: (1) exit site infection – erythema, tenderness, induration, purulent discharge and growth on culture. (2) Catheter tip colonization – growth on culture of the distal segment ofthe CVC with clinical signs of infection. (3) CRBSI –isolation of the same organism from the catheter tip culture and from at least one of the two blood cultures, along with signs and symptoms of infection. Thus, patients with clinical signs of infection and in whom the CVC tip showed a positive growth without associated bacteremia was considered as catheter tip infections. Whereas patients with clinical evidence of infection along with positive growth of the same organism on blood culture as well as CVC tip positive culture were diagnosed to have CRBSI.

Results

A total number of 542 CVC (15% = 81 CVC in paediatric patients) were inserted using Seldinger technique. The incidence of arterial punctures occurred more common with SV cannulation in 16.6%, followed by femoral vein 11.1% and IJV cannulations 4.1 % (figure 1). The incidence of haematomas was 4.4% with SV, when compared to 2.5% with IJV and 2.2%with femoral vein cannulations. However, hematomas subsided without any intervention. 2.2% had pneumothorax with SV, when compared with 0.95% with IJV cannulations. 13.3% developed sepsis with femoral vein, when compared to 5% with SV and 2.5% with IJV cannulations.



	Arterial Punctures	Haematoma	Pneumothorax	Thrombosis	Sepsis
IJV	4,1	2,5	1,0	1,0	2,5
SV	16,6	4,4	2,2	3,3	5,0
FV	11,1	2,2	0,0	8,8	13,3

Figure 1. *CVC complications in differente routes*

CVC infections are mainly caused by Acinetobacter, Enterobacteriaceae and Pseudomonas. Reports from other hospital in India show similar pattern of infection. [5]

A comparison among three central venous catheterization sites based on culture results showed that the infection rate was 4.2% (2.8 % in paediatric patients). The infection rate at the IJV, SV and femoral vein site showed the infection rate of 5%, 2.5% and 13.3% respectively. There was occurrence of 8.8% thrombosis in femoral vein, 3.3% in SV and 1.5% in IJV cannulations.

Discussion

CVC are an important tool in the ICU and operation room. The use of CVCs is associated with both mechanical and infectious complications. [6] All infected CVC were removed and the patients were treated with appropriate antibiotics. CVC-related systemic infections were found in 13.3% of patients with femoral catheters, 5% with subclavian catheters and 2.5% with internal jugular catheters. Bacterial cultures were done on the tips of the catheters using endothelial brushing and maki roll techniques. Catheter-related infection (CRI) is a well-known complication in critically ill patients receiving total parenteral nutrition.[7] Micro-organisms may travel from the skin puncture site along the external surface of the catheter or from the hub through the lumen of the catheter, to be shed into the circulation causing bacteremia and sepsis. The incidence of sepsis is said to be about three times greater with multiple-lumen catheters than with single-lumen catheters. [7]

Skin organisms colonizing in the distal intravascular tip of the catheter ultimately cause blood stream infection. [8] Hub contamination is more common in long-term catheters because such catheters often have to be intercepted and manipulated. [9]

Organisms are usually introduced into the hub from the hands of medical personnel, from this contaminated hub, the organisms migrate along the internal surface of the catheter, where they can cause a bloodstream infection.[9] Fever with chills and rigors should always be considered as CRI when there is no other identifiable source of infection is present. Clinical findings are unreliable for establishing a diagnosis of CRI. [9]

Catheter-associated infections can be considered for local or systemic infection. Local infection includes

simple colonization or true infection that may involve the site or tunnel. Local inflammatory signs at the catheter's portal of entry or tunnel have a highly predictive value for infection but its absence has a very poor negative value.[10] The skin insertion site and the catheter hub are by far the two most important sources; approximately 65% of CRI originate from the skin flora, 30% from the contaminated hub and 5% from other pathways.[11]

Quantitative blood culture techniques have been developed as alternatives for the diagnosis of catheter-related blood stream infection in patients for whom catheter removal is undesirable because of limited vascular access. [12] The practice of routinely changing catheters in a predefined time period to reduce the risk of CRI is referred to as "scheduled" replacement. There is no report from the literature that catheter replacement at scheduled time intervals will reduce the CRI rates. [13]

The risk of complication during the insertion or exchange of CVCs has been well documented. The majority of complications involve mechanical problems associated with insertion. Although cardiac arrhythmia has been acknowledged as a possible complication, its incidence has never been quantified particularly in paediatric patients. [14]

In critically ill patients, barotrauma and puncture of an incompressible artery are probably the most common mechanical complications and can be life-threatening. The rate of mechanical complications has ranged from 0–12% (2-16% in paediatric patients), according to the experience of the operator and the definition of complications. [15] Mechanical complications include arterial puncture, pneumothorax, mediastinal haematoma, haemothorax and injury to adjacent nerves. The recent introduction of more flexible catheters and of the J guide-wire insertion method has decreased the rate of severe mechanical complications. [16] In our study, the mechanical complication rate was 13.3%.

In the meta-analysis by Ruesch and coworkers,[17] arterial punctures were significantly more common with the jugular vein than with the subclavian vein approach (6 trials, 2010 CVCs; 3% *vs.* 0.5%; relative risk (RR) 4.7, 95% confidence interval (CI) 2.05–10.77). However, bleeding from a punctured internal carotid artery can usually be controlled by manual compression. A hematoma may occur, particularly when a dilator or pulmonary artery catheter is inserted. A large hematoma may produce rare but serious complications including airway obstruction and accidental tracheal puncture (very important and dangerous in neonates and infants), retrograde aortic dissection, arteriovenous fistula or cerebrovascular events in patients with occlusive atheromatous disease of the carotid artery. [17]

Most studies have demonstrated that the use of prophylactic antibiotics is associated with reduction in the rate of catheter-related bloodstream infections.[18] However, this use of antibiotics is discouraged because of the concern that it will encourage the emergence of antibiotic-resistant organisms.[19] As with most medical procedures, the level of experience of the physician reduces the risk of complications.[20] Insertion of a catheter by a physician who has performed 50 or more catheterizations is half as likely to result in a mechanical complication as an insertion by a physician who has performed fewer catheterizations.[20] The incidence of mechanical complications after three or more insertion attempts is six times higher than the rate after one attempt.[21] Hence, if a physician is unable to insert a catheter after three attempts, he or she should seek help rather than continue to attempt the procedure.

Conclusions

The choice of the best central venous access for a particular patient is based on the clinical condition, rate and the severity of failures and complications. Based on our experience, internal jugular venous access is associated with a low rate of severe complications like arterial punctures, hematoma, pneumothorax, thrombosis and sepsis in the intensive care unit as compared with subclavian vein and femoral vein access. We conclude that CVC plays an important role in

treating critically ill patients in an ICU but may cause serious multiple complications if proper precautions are not taken. Ultrasonography guided CVC are best performed (we recommend it in paediatric patients) [22] to prevent mechanical complications and improve patient safety.

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