Mechanical and infectious complications developing due to central venous catheterizations in the Emergency Department

Hayri Ramadan¹, Nalan Metin Aksu¹, Meltem Akkas¹, Mehmet Husamettin Akkucuk¹, Figen Coskun², Yesim Cetinkaya Sardan³

¹Department of Emergency Medicine, School of Medicine, Hacettepe University, Ankara, ²Department of Emergency Medicine, Ankara Training and Research Hospital, Ulucanlar Ankara, ³Department of Internal Medicine, Section of Infectious Diseases, School of Medicine, Hacettepe University, Ankara; Turkey

ABSTRACT

Aim To investigate the rate of catheter-related bloodstream infections (CRBSI) and mechanical complications due to central venous catheter (CVC) insertion in the emergency department (ED) and the contributing factors.

Methods A total of 236 patients who were admitted to our ED and underwent CVC insertion between July 2008 and July 2009 were included in this prospective study. The CVC indications, the urgency of the insertion (emergency or elective), catheter complications (mechanical or CRBSI) and the compliance of the emergency physician placing the catheter with infection control and prevention measures were investigated.

Results The CVC had been inserted urgently in 103 (44%) of the cases and mechanical complication rates in these patients were higher than those receiving it electively (p<0.05). Our total mechanical complication rate was 27 (11.4%) with the highest rate for femoral catheter (FC). The CRBSI rate was 5/1000 catheter days. None of the physicians inserting a catheter ensured hand hygiene before the procedure.

Conclusion The FC is used as the most common access route for a CVC in our ED but CRBSI rate and mechanical complication rate were lower than in the literature. We believe that increasing compliance with infection control and prevention measures, especially hand hygiene, can further decrease the CRBSI rate in the ED.

Key words: catheter-related infections, catheterization, central venous, complications, infection control
INTRODUCTION

Vascular access must be obtained in a secure and quick manner for most patients presenting at the emergency department (ED) (1). It is difficult to insert a peripheral vascular line at some situations such as cardiopulmonary arrest, trauma, shock and burns, which are usually accompanied by peripheral vascular collapse. It is therefore unavoidable that these patients undergo a central venous catheter (CVC) insertion (2-4). Central venous catheter indications include emergency dialysis, central venous pressure (CVP) monitoring, pacemaker placement and total parenteral nutrition, which lead to an ever-increasing need for CVC insertion in the ED (4). This increase had led to more frequent CVC-related complications in daily practice. These complications increase patient mortality and morbidity and also cause an increase in costs (2).

Central venous catheter related complications are evaluated in two groups as mechanical problems and catheter-related bloodstream infection (CR-BSI) (2). In the literature, there are a few studies on complications related to CVC in the ED. In these studies, mechanical complications and CR-BSI are generally evaluated separately (1-6).

We investigated the frequency of both CRBSI and mechanical complications developing due to the CVC in the ED and the contributing factors to address these complications in our study.

PATIENTS AND METHODS

Approximately 30,000 patients present at the Hacettepe University Emergency Department annually. The 236 patients who received a CVC between July 2008 and June 2009 were included in this prospective study. Permission was obtained from the Medical Studies Local Ethic Committee (HEK 08/127-8).

Patients were classified according to the indication of CVC as urgent or elective. Emergency placement was the method of choice (inclusion criteria) for patients who had renal dysfunction and electrolyte imbalance and needed emergency dialysis, in which a peripheral vascular route could not be obtained and emergency medical treatment was required, with severe general body trauma, and in the patients with cardiopulmonary arrest.

The central venous catheters were applied electrically for the rest of patients (patients with renal dysfunction but did not require immediately dialysis, patients who needed placement of a pacemaker, patients who had need total parenteral nutrition, plasmapheresis, CVP monitoring or longstanding IV treatment).

Study protocol

The area of insertion place was cleaned with povidone iodine before the CVC insertion and local anesthesia was administered with 2% prilocaine. A double-lumen 12 F catheter was placed with the Seldinger technique in all CVC procedures. All patients who were placed a subclavian catheter (SC) or internal jugular catheter (IJC) were monitorized during the procedure. A posteroanterior chest x-ray was obtained from every patient with an inserted IJC or SC to detect potential complications and locate the catheter.

A “CVC insertion form” was created for each patient (age, gender, reason for emergency presentation, CVC location and reason for insertion, complications and CVC removal time). This form was completed by the investigators participating in the study. The physicians performing the catheter insertion were free to choose the way of central route. Accepted catheter dysfunction causes were catheter displacement, thrombus development within the catheter or the development of a fibrin sheath. In these situations, the catheter was removed or replaced.

A “CVC insertion monitoring form” was created for an investigation of the infection risk during CVC placement. This form was completed by the nurse watching the CVC procedure without the physician’s knowledge. This form was used to determine whether the CVC was placed under emergency or elective conditions, and the state of compliance with infection control and prevention measures.

Measures

All patients were followed up daily for bloodstream infection signs and symptoms after catheter placement. The CRBSI was defined as the presence of at least one positive hemoculture (including bacteremia/fungemia), the presence of accompanying clinical infection manifestations (fever, chills and/or hypotension) and the lack
of a source of infection other than the catheter (7). The presence of at least one of the following criteria used for the confirmation of the diagnosis: positive semiquantitative (>15 CFU/catheter segment) or quantitative (>103 CFU/catheter segment) culture whereby the same organism (species and antibiogram) was isolated from the catheter segment and peripheral blood; simultaneous quantitative blood cultures with the ratio of CVC versus hemoculture was >5:1; differential period of CVC culture versus peripheral blood culture positivity of >2 hours. The CRBSI rate was calculated using the formula:

\[
\text{CRBSI rate} = \frac{\text{the number of CRBSI cases developed in a unit within a defined period/the number of CVC days in the same period}}{1000}
\]

**Data Analysis**

The numerical variables were shown as mean, standard deviation, median, and minimum and maximum values while the qualitative variables were shown with numbers and percentages. The Mann-Whitney and Kruskal-Wallis tests were used to determine whether there was a difference between the groups for numerical variables. The chi square test was used to look for any difference between the qualitative variables. The significance level was set at \(p<0.05\).

**RESULTS**

A total of 236 patients (mean age: 63±16 years; 110 females and 126 males) was included in this study. The most common route for the CVC was the right femoral catheter (FC), in 113 (47.9%) patients, followed by the right IJC, in 68 (28.8%), right SC in 32 (13.6%), and left FC in 23 (9.7%) patients. The reason for placement was dialysis in 109 (46.2%), peripheral vascular route problem in 55 (23.3%), CVP monitoring in 34 (14.4%) and the others in 38 (16.1%) cases. The most commonly used access route for CVC was FC, especially used for dialysis. The CVC duration was 1-32 days with a median value of five days. Of the patients who were placed a CVC, 130 (55%) were followed up in the ED and 106 (45%) as inpatients in a relevant ward. Central venous catheter related complications were presented in 36 (15.2%) and not presented in 200 (84.8%) patients. These complications were mechanical in 27 (11.4%) and CRBSI in nine patients (3.8%) (Table 1). Catheter-related bloodstream infection due to CVC was found in nine (3.8%) cases. A simple size of 236 achieves 88% power to detect a CRBSI rates with 0.05 tolerance value. The catheter duration median value was five days in the 227 (96.2%) cases without CRBSI while eight days in the nine (93.8%) cases with CRBSI. The CRBSI rate was found to be 5/1000 catheter days. Comparison of catheter durations in patients who developed and did not develop CRBSI showed a longer median duration in the first group but this was not statistically significant. It was not found significant effect of CVC insertion place on CRBSI development (Table 2).

<table>
<thead>
<tr>
<th>Catheter location</th>
<th>Absent</th>
<th>Present</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right IJC</td>
<td>65 (95.6%)</td>
<td>3 (4.4%)</td>
<td>68 (100%)</td>
</tr>
<tr>
<td>Right SC</td>
<td>31 (96.9%)</td>
<td>1 (3.1%)</td>
<td>32 (100%)</td>
</tr>
<tr>
<td>Right FC</td>
<td>109 (96.5%)</td>
<td>4 (3.5%)</td>
<td>113 (100%)</td>
</tr>
<tr>
<td>Left FC</td>
<td>22 (95.7%)</td>
<td>1 (4.3%)</td>
<td>23 (100%)</td>
</tr>
</tbody>
</table>

CRBSI, Catheter-related bloodstream infection; IJC, internal jugular catheter; SC, subclavian catheter; FC, femoral catheter

The CVC was inserted with urgent indication in 103 and with an elective indication in 133 patients. The rate of a mechanical complication was 16.5\% (n=17) in CVC cases having the procedure done urgently and 7.5\% (n=10) in those having the procedure done electively. The higher mechanical complication rate in patients undergoing urgent procedures was statistically significant (\(p<0.05\)). However, no statistically significant difference was found between urgent and elective catheter insertion for CRBSI rates (4.5% and 2.9%, respectively).

None of the physicians complied with hand hygiene rules (washing/disinfecting hands before putting on the sterile gloves) before the procedure.

**Table 1. Distribution of mechanical complications by catheter location**

<table>
<thead>
<tr>
<th>Catheter location</th>
<th>Number (%) of patients with mechanical complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Absent</td>
</tr>
<tr>
<td>Right IJC</td>
<td>62 (91.2)</td>
</tr>
<tr>
<td>Right SC</td>
<td>29 (90.6)</td>
</tr>
<tr>
<td>Right FC</td>
<td>101 (89.5)</td>
</tr>
<tr>
<td>Left FC</td>
<td>17 (73.9)</td>
</tr>
<tr>
<td>Total</td>
<td>209 (88.6)</td>
</tr>
</tbody>
</table>

IJC, internal jugular catheter; SC, subclavian catheter; FC, femoral catheter
DISCUSSION

The number of ED and hospitalized patients in need of a CVC keeps increasing and the indication spectrum is continuously expanding. There is only a limited number of studies on CVC applications in the ED, while the relevant studies on intensive care and ward patients are more variable and numerous (1,2,4,6,8-10). These studies in the ED have generally evaluated infections or mechanical complications due to CVC but the two complication groups have not been assessed together. The aim of the present study was to evaluate the combined complication rates in the ED and to address an inadequacy in the literature.

The most common CVC insertion indications were reported variously in the literature, such as CVP monitoring, vascular route problem, the need for treatment from the central vein or dialysis (3,5,6). In our study, the most common CVC insertion indications were dialysis, followed by vascular route problem and CVP measurement, similar to the studies above.

The most common routes for the CVC were reported the internal jugular vein (3,6) and subclavian vein (1,4,5). Authors that prefer an IJC state that this method leads to lower rates of serious and fatal complications (such as pneumothorax and hemothorax) (3,6). Authors that prefer an SC state that they use this method more frequently as the patients included in their studies are mostly trauma patients and therefore need cervical immobilization. Moreover, the SC route is also less infection risk together with a lower arterial puncture rate (1,4,5). Femoral vein was often chosen as the CVC route in our ED. We believe that this is because most of the patients who present at our ED are cachectic oncologic patients while FC can be placed easily by even less experienced staff. Femoral catheter was found to be frequently preferred in patients for dialysis in parallel with the literature (2).

Central venous catheter complications can be classified into two groups as mechanical or CRBSI. Our mechanical complication rates were low (11.4%) while this rate is 12-17.4% in the literature (5,6). Steele et al. have found a low (3.4%) mechanical complication rate (1). However, we found that some parameters used in our study and other literature data such as arterial puncture, thrombosis, small hematomas and catheter blockage had been omitted in Steele’s study and could have led to low complication rates. The most common mechanical complications for FC have been reported as arterial puncture, vein thrombosis and infection while the relevant pathologies are pneumothorax and catheter dysfunction for SC and arterial puncture and arrhythmia for IJC (4,8,9-12). We also found the most common mechanical complication to be arterial puncture and hematoma for FC, pneumothorax for SC and catheter obstruction for IJC.

Complications such as CRBSI and thrombosis are related to the indwelling time of the catheters. A prolonged duration increases the risk of both thrombotic complications and CRBSI. The most common thrombotic complication causing catheter dysfunction is fibrin sheath development that results in a foundation for infection (13,14). We found the median catheter duration to be five days and there was no relation between this duration and the frequency of mechanical complications.

Infection is one of the most important complications developing due to CVC and is known to be directly associated with the catheter duration. A study by Trick et al. has found CRBSI rates of 4.4/1000 catheter days (24/1000 catheter days for ED and 18/1000 catheter days for other wards) and reported that CRBSI developed most commonly after FC (2). A CRBSI rate of 7.2/1000 catheter days was reported by Nagashima et al. (3). They suggested that an SC should be preferred to other catheterization locations with regard to the infection prevention as well due to its low infection risk (3). Other previous studies have suggested also preferring SC to decrease the CRBSI rate (9,15).

Table 3. Compliance of the physician placing the catheter with infection control and prevention measures

<table>
<thead>
<tr>
<th>Observed variable</th>
<th>Inserting person</th>
</tr>
</thead>
<tbody>
<tr>
<td>Providing hand hygiene</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Providing skin antisepsis</td>
<td>236 (100%)</td>
</tr>
<tr>
<td>Sterile drape usage</td>
<td>234 (99.2%)</td>
</tr>
<tr>
<td>Sterile glove usage</td>
<td>236 (100%)</td>
</tr>
<tr>
<td>Sterile apron usage</td>
<td>134 (56.8%)</td>
</tr>
<tr>
<td>Cap usage</td>
<td>105 (44.5%)</td>
</tr>
<tr>
<td>Mask usage</td>
<td>112 (47.5%)</td>
</tr>
<tr>
<td>Preserving field sterility</td>
<td>235 (99.6%)</td>
</tr>
<tr>
<td>Full compliance with infection control and prevention measures</td>
<td>0 (0%)</td>
</tr>
</tbody>
</table>

(Tables 3). In conclusion, we found the rate of full compliance with infection control and prevention measures to be 0%.
Most recently, Le Master et al. have reported a CRBSI rate of 1.93/1000 catheter days in the ED (16). However, we believe that this low rate can be due to the exclusion of the patients who died and catheters placed for dialysis purposes.

We found the CRBSI rate in our study (5/1000 catheter days) to be lower than the rates found in other studies with ED, except the Le Master et al study (16). The median catheter duration was longer in the group who developed CRBSI (eight days) than in those who did not (five days) \( (p >0.05) \). We found the lowest CRBSI rate with SC in parallel with the literature but we cannot find a significant effect of the CVC insertion route on CRBSI development. We believe that the lack of statistical significance is due to our low number of CRBSI cases. The low CRBSI rates in FC in our study may be due to the low number of CRBSI cases, the short catheter duration and the care shown by the physicians placing the catheter regarding sterility, taking into account that the CRBSI risk could be high in this region.

The CVC was placed urgently in 44% of the cases and the mechanical complication rates in these cases were approximately twice as high as seen in those undergoing elective procedures \( (p<0.05) \). High mechanical complication rates have also been detected in patients where these catheters were placed with emergency indications in the literature. The reason for this difference could be the generally poor state of emergency CVC patients, and the need to complete the procedure as quickly as possible.

We believe that the lack of ensuring hand hygiene before the procedure is due to the working conditions of the ED and lack of training. Our infection rates were probably not high, despite the 44.5% low rate of full compliance with parameters other than hand hygiene, due to the almost 100% use of skin antiseptics, preservation of site sterility and the use of sterile gloves and large sterile drape. Although our CRBSI rate was lower than in other studies in the ED, the higher rates than reported for wards and intensive care units in the literature may be due to the lack of conformance with hand hygiene rules in our study. Providing training to the persons placing the CVC could increase compliance with these rules, making the CRBSI rate approach zero. Other studies evaluating CRBSI rates in the ED did not include compliance with sterility rules in the evaluation. More detailed studies investigating compliance with sterility rules in ED are therefore needed.

Our CRBSI and mechanical complication rates were lower than in other studies although the femoral vein was most commonly used as the CVC entry route in our ED. Hand hygiene during the procedure was not used in any patient but the full compliance with skin antiseptics, preservation of site sterility, and the use of sterile gloves and a sterile large drape kept our ED CRBSI rate low. However, ensuring full compliance with infection control and prevention measures, especially hand hygiene, could decrease the CRBSI rate even further, making it approach zero.

ACKNOWLEDGEMENT

The authors thank Sevilay Karahan (MSc) for statistical analysis of this study.

FUNDING

No specific funding was received for this study.

TRANSPARENCY DECLARATIONS

Competing interests: none to declare.

REFERENCES


