Complications of Central Venous Catheterization

Roberto E Kusminsky, MD, MPH, FACS

It is estimated that millions of central venous catheters (CVCs) are inserted yearly in US hospitals.[1] The profound impact of the complications associated with CVC use is so important that efforts to minimize and prevent their occurrence should be a routine element of quality improvement programs. This review aims at centralizing the evidence currently available and presenting it as a ready reference that could assist in estimating the magnitude of the problem and formulating prevention initiatives. Additionally, emphasis is placed on the growing body of information that supports the use of ultrasonography-assisted insertion (UAI) as a superior technique to decrease adverse events from CVC insertion. From a clinical and practical point of view, which better correlates with usage issues, CVC complications are best classified as secondary to insertion, indwelling, and extraction practices.

RISK FACTORS

The incidence of mechanical complications is modified by a variety of factors:

1. Inexperience, variably defined but with a consistent relationship between less experience and the rate of complications.[2,3]
2. Number of needle passes, with the incidence of complications rising with two venopunctures[2-5] to a sixfold increase with three or more.[6]
3. Body mass index > 30 or < 20,[4,7] previous catheterizations, and severe dehydration or hypovolemia are factors that increase risk.
4. Coagulopathies do not appear to increase the risk of percutaneous insertion[8-11] if appropriate precautions are taken,[12] such as transfusing thrombocytopenic patients with platelets until a count of 50,000 or higher is reached, and fresh-frozen plasma in patients with elevated prothrombin and partial thromboplastin times. Administration of antihemophilic globulin before subclavian vein (SCV) catheterization has led to reports with similar conclusions in patients with hemophilia.[13] Even heparinization does not appear to increase the risk of bleeding or hematoma during internal jugular vein (IJV) insertion.[14] Although coagulopathies are not a clear contraindication,[15] the IJV or femoral vein (FV) appears to be the compressible access site chosen by many authors for patients with coagulation disorders.[16,17]
5. Large catheter size, such as those used for dialysis, appears to influence the risk of vascular complications of insertion.[18]
6. Failure to catheterize is influenced by factors such as experience,[2,3,19] previous catheterizations, previous catheterization attempts, and previous operation or radiotherapy in the anatomic region of interest.[4,6]
7. Unsuccessful insertion attempts are the strongest predictor of insertion complications.[6] Overall rates of unsuccessful insertion attempts for IJV access have been reported at 12%[20] and 12% to 20% for SCV and IJV in adults[19] and infants weighing < 10 kg.[21] Among patients who fail attempts at catheterization, complications develop in 28%.[6]

Overall incidence

Complications associated with CVC insertion fluctuate according to their definition and the correlation with the multiple factors that influence their occurrence, ranging between 5% and 19%.[19,22] Femoral catheterization has a higher incidence of mechanical complications than SCV or IJV access,[22] and can be associated with severe injury if an inadvertent femoral artery puncture is too high and is followed by anticoagulation.[23] IJV and SCV catheterization carry similar risks of mechanical complications,[1] although IJV insertion has been reported to have a higher incidence of mechanical complications than SCV in elective[24] and emergency situations.[25] A prospective, comparative study suggests that during cardiac arrest the catheterization success rate can be higher for SCV than for FV access.[26]

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From the Department of Surgery, West Virginia University, Robert C Byrd Health Sciences Center, Charleston Division and Charleston Area Medical Center, Charleston, WV.

Correspondence address: Roberto E Kusminsky, MD, MPH, FACS, West Virginia University, 3110 MacCorkle Ave, Charleston, WV 25304.

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Abbreviations and Acronyms

CVC = central venous catheter
FV = femoral vein
IJV = internal jugular vein
SCV = subclavian vein
UAI = ultrasonography-assisted insertion

Because the complication rate decreases with training,[27,28] designing a standardized method of CVC insertion[29] is a logical process to promote prevention and decrease the incidence of adverse events.[1,30,31] Standardization can also establish management guidelines for some complications that commonly follow CVC insertion, such as pneumothorax.[32] Standardization can establish a best-practice approach based on evidence, and it can provide an answer to the questions sometimes raised about the competence of house officers.

The advantages of UAI of CVCs have been reported as far back as 1978,[33] and the body of literature supporting its adoption continues to expand. There is now abundant evidence to establish UAI as the safest method to prevent or decrease overall and specific complications of insertion. Reports of the advantages of ultrasonography over the anatomic landmark method support the findings of risk reduction[20,34] and improved cannulation success[20,34-36] for all access sites—FV[37], SCV, IJV[36]—in adults and children[36,38] and in different settings.[39] In addition, the gap between experienced and inexperienced operators has been reported to disappear when UAI is used.[40] Conversely, UAI can be of help to a skillful operator who is otherwise unable to cannulate.[41] There are reports disputing these results,[42] although some of the discrepancies have been reported in studies in which ultrasonography was not used in real-time mode.[6]

Insertion complications

Pneumothorax is one of the most common complications of CVC insertion, reportedly representing up to 30% of all mechanical adverse events.[43,44] Its incidence varies between 0%[7,24] and 6.6%,[45,46] with higher incidences when the number of needle passes increases,[4] in emergency situations,[47-49] and when the catheters inserted are large, such as those used for dialysis.[45] A 1% to 1.5% incidence is more consistently reported.[6,32,50] Most of the evidence points toward a higher incidence of pneumothorax when the SCV is cannulated, as compared with the IJV.[5,24] SCV catheterization has occasionally been linked to a lower incidence of pneumothorax than IJV access.[51]

Delayed pneumothorax has been reported to occur in 0.5%[44,52] to 4% of the insertions,[45] but the incidence is quite a bit lower in some studies.[53] Symptoms commonly appear within 6 hours but not in all patients,[53] which calls for the need to exercise caution and increased awareness in those cases where the insertion was difficult,[54] despite the ostensible early lack of complications.

A standardized treatment algorithm of CVC-induced pneumothorax can lead to good results with safety, improvements in patients' comfort, and decreases in length of stay in adults[32,55-57] and children.[58] Such an algorithm should include elements of awareness and treatment of reexpansion pulmonary edema,[59,60] particularly if patients are treated on outpatient basis.[57] Re-expansion pulmonary edema is estimated to occur in 1% to 14% of patients with pneumothorax.[59,61]

Clinician-performed bedside ultrasonography allows the diagnosis of pneumothorax to be made immediately, with a high degree of sensitivity and with better accuracy than supine chest films and equal to that of CT scan.[62-64] This approach has not yet gained widespread acceptance, is operator-dependent, and patient selection and equipment can influence the results.[65]

Malpositioning of a CVC has been associated for years with problems of local toxicity, perforation, and venous thrombosis and its sequelae. In the past, a considerable percentage of catheters were left within the right atrium,[66] but today the consensus in the literature opposes this practice[67] because of the increased risk of perforation. The debate about the validity of this recommendation continues to surface[68,69] and many believe that the purported advantages of a CVC tip in the atrium are associated with minimal risks.[69-71] These disagreements produce difficulties with the interpretation of the true incidence of malposition, particularly if the analysis includes information derived from older series, when the definition of malposition, catheter length, and angle of incidence was not a common element of discussion, and when repositioning was not a major concern.[72] Today, malposition includes the recognition that an angle of incidence of the CVC tip against the wall of the vessel $>$ 40 degrees carries an increased risk of perforation.[73] To avoid the tip from abutting against the wall of the vein at an inappropriate angle, it is best to approach left-sided insertions with a 20-cm catheter and the right-sided ones with a 16-cm catheter[74,75] in adult patients.