Accurate Placement of Central Venous Catheters Using a 16-cm Catheter

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We determined if use of 16-cm central venous catheters (CVC) minimizes dangerous intracardiac catheter placements. We conducted a prospective study in a large community teaching hospital. Consecutive patients (n = 127) who required a CVC via either the internal jugular (IJV) or the subclavian vein (SCV) were assessed using 16 (n = 102) or 20-cm (n = 25) catheters. The main outcome measurements were: (1) intracardiac placement of central venous catheters, and (2) relationship of right- or left-sided internal jugular or subclavian vein insertions to intracardiac catheter placement. Use of a 20-cm CVC resulted in 14 of 25 (56%) intracardiac placements compared with 11 of 102 (11%) using a 16-cm catheter (p < 0.0001). All intracardiac placements with the 16-cm CVC were from right-sided approaches: IJV 7 of 38 (16%), SCV 4 of 18 (18%). Use of a 16-cm CVC to access the central circulation from either the SCV or the IJV results in a significantly greater proportion of safe catheter placements than using longer CVCs, and it should become the standard of care.

We recently reported the high incidence of intracardiac central venous catheter (CVC) placements using 20- or 30-cm central venous catheters [1]. CVCs are frequently placed and then left within the heart despite postprocedure films that reveal tip malposition [1,2]. Extracardiac CVC tip placement could eliminate the major mechanical cause of mortality related to this procedure: right atrial perforation and subsequent tamponade [3-9]. A simple way to achieve this result without materially changing the way most physicians perform this procedure would enhance patient safety.

We previously determined that the average safe (i.e., catheter tip above the right atrium) insertion distance for CVCs placed via the internal jugular or subclavian vein was 16.5 cm [1]. We hypothesized that by using 16-cm CVCs placed into the internal jugular or subclavian veins to their full length, we would substantially reduce the incidence of intracardiac catheter tip placement. To test this hypothesis, we conducted a prospective trial using 16-cm CVCs to determine the incidence of intracardiac tip placement.

Materials and Methods

This study was approved by the Institutional Review Board at Baystate Medical Center. A total of 127 patients were prospectively evaluated for the location of CVC (Arrow International, Inc, Reading, PA) tips placed by either the internal jugular or subclavian veins. The incidence of malpositioned catheters, using our standard 20-cm CVC, was determined prospectively in a total of 25 patients. These catheters were placed using the accepted technique of estimating approximate distance of insertion by measuring the catheter on the patients' chest or by using an operator-determined preset distance from an anatomical insertion location. These catheters were not routinely placed to their entire length; 102 16-cm CVCs were placed to their entire length. All catheters were placed by medical, surgical, or anesthesia residents under the supervision of the attending intensivist. Immediate postprocedure films were evaluated for the location of catheter tips by
a radiologist. The caval-atrial junction was determined to be at the junction of the vertical edge and the lower convexity of the right mediastinal contour. The catheter tip was determined to be in either a dangerous location (within the heart) or a safe location (above the superior vena cava–right atrial junction).

Statistics

Comparisons of the proportion of catheters placed in the heart were done using Fisher's exact method [10].

Results

Using 20-cm CVCs, 14 (56%) of 25 catheters were placed within the right atrium (RA); 11 of 102 (11%) of the 16-cm CVCs had catheter tip locations within the RA ($p < 0.0001$) (Fig 1). The majority of the 16-cm catheters were placed in the superior vena cava (SCV) outside the heart. Thirty-five (34%) and 67 (66%) catheters were placed from left or right side approaches, respectively. The 11 16-cm catheters within the heart were all placed from the right side; 16% (7/45) by the internal jugular vein (IJV) and 18% (4/22) by the SCV (Fig 2). The distance within the heart, beyond the SVC–right atrial junction, ranged from 0.5 to 4.5 cm for the right IJV and from 1.0 to 2.5 cm for the right SCV approaches. By location, no catheter tips placed via left-sided approaches were within the heart (see Fig 2).

Discussion

It is widely accepted that CVC tips should not be placed in or allowed to migrate into the heart [11]. A Food and Drug Administration (FDA) Task Force has even recommended periodic radiographs to ensure safe catheter tip location outside the heart [12]. Catheter manufacturers now routinely include a warning notice with the insertion materials specifying that the tip be placed in an extracardiac location [13]. Regardless, most catheters sold in the United States are longer than necessary (Fig 3) (Stuckert DH. Personal communication, 1994). De-

Fig 1. Use of a 16-cm CVC minimizes right atrial catheter tip placement: 11 vs 56% ($p < 0.0001$).

Fig 2. Of the 16-cm catheters, no catheters placed from left-sided approaches terminated within the heart. The relative frequencies of right atrial tip location are shown for each anatomical insertion location.

Fig 3. Estimated market for various size catheters sold in the United States as a percent of total; 20- and 30-cm catheters continue to dominate the market share.
spite these warnings and the FDA task force recommendations, our current and prior study using longer catheters showed that between 47 and 56% of all catheter tips terminated within the RA when using conventional placement techniques [1]. Locating a CVC tip within the heart on a postprocedure film rarely results in catheter repositioning [1,2]. Repositioning takes time and requires the further expense of an additional radiograph. An electrocardiogram-guided technique using the catheter tip as an electrode identifies the sinoatrial node and facilitates catheter tip placement in the distal SVC. Once the SA node is located electrocardiographically, the catheter is withdrawn to the distal SVC. In our prior study using this technique, we eliminated tip malposition; however, acceptance and application of this technique are not known [1]. Wider dissemination of safe insertion distances will hopefully result in closer attention to this aspect of central venous cannulation. The simplest and the most cost-effective method to avoid intracardiac catheter tip placement may be to choose an appropriate catheter length.

No catheters placed from the left side in our study terminated within the heart. The distance to the RA from a left-sided approach is greater than from the right side. A standard insertion depth of 13.5 and 11.5 cm from the right subclavian and right IJV, respectively, would have eliminated intracardiac placement in the 11 patients whose catheters (placed from the right side) terminated within the heart. Appreciation of the shorter distance required to safely place CVCs by right-sided approaches may lead to further refinement of this technique. Other factors, including body size, sex, length of the neck, and specific insertion site, all require further study.

Although catheter tips can be safely placed outside the heart using shorter catheters, complications related to catheter angulation relative to the SVC should be formally investigated. SVC perforation by CVCs does occur and carries significant morbidity [14–18]. This complication seems to be related to an acute angulation between the SVC and the SVC wall [14,15]. Distal tip location in the SVC above the RA is associated with less acute angulation of the catheter compared with more proximal locations within the SVC for all approaches other than the RI [18–20]. CVCs placed via the right IJ typically end parallel to the SVC wall and minimize catheter tip to vein angles (Fig 4). These aspects of central venous cannulation related to the use of shorter catheters will need further study.

Ideal catheter placement will not totally eliminate mechanical complications related to this procedure. Catheter position is not fixed, and toxicity or other

![Fig 4. Catheter positions relative to the SVC based on insertion site and proximity to the right atrium. Catheter angulation relative to the SVC is minimized when the catheter tip is in the distal SVC near the right atrium for all insertion locations other than the RIJ. RIJ insertions tend to be parallel to the vessel wall regardless of location within the SVC.](image)

sclerosing properties of intravenous solutions can have a role in vessel damage.

Conclusions

Use of 16-cm CVCs for access to the central circulation from either the internal jugular or the subclavian vein approaches results in a significantly greater proportion of safe catheter placements than when 20-cm CVCs are used, and it should become the standard of care. Catheters longer than 16-cm should be reserved for special anatomical considerations related to patient size or more peripheral insertion locations. Further studies should be initiated with shorter catheters to make sure there is no increase in complications related to SVC perforation. Use of even shorter catheters has the potential
to eliminate intracardiac placements when using right-sided approaches.

References

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