Blind placements of peripherally inserted antecubital central catheters: initial catheter tip position in relation to carina

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Background. We investigated how often blind placement of peripherally inserted central catheters (PICCs) through the antecubital veins results in a correct tip location in relation to carina and evaluated the inter-observer agreement in locating the tip of PICCs in plain radiography with digital imaging.

Methods. In this study, 202 suitable chest radiographs with PICCs out of 803 patients were identified. An initial audit on the tip of these catheters in relation to carina was done by a consultant anaesthetist and was recorded as the first observer. The same sets of CXRs were examined by a consultant radiologist and the tips were identified and recorded as the second observer. Inter-observer agreement was assessed.

Results. In 75 of 202 (37%), PICCs had a central tip location in relation to the carina. Fifty-five of 131 (42%) right-sided catheters had a central location compared with 20 of 71 (28%) of the left-sided catheters. The tip position for right-sided catheters was most frequently centrally located whereas the tip for left-sided catheters was most commonly positioned in the ipsilateral innominate vein. There was excellent agreement between the observers in reporting the tip of PICCs at all positions (kappa=0.87) including central locations (kappa=0.83).

Conclusions. Right antecubital PICCs are more likely to be placed in the central location in relation to the carina. PICCs inserted through the left antecubital veins need to be pushed further down to aim for a central location. Inter-observer variability in identifying the tip of PICCs is least with the introduction of digital imaging.


Keywords: peripherally inserted central catheters; carina; central location; inter-observer agreement

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Peripheral inserted central catheters (PICCs) play a vital role in various clinical settings including the perioperative care of surgical patients. PICCs offer the advantages of placement under local anaesthesia, a low risk of major haemorrhage, no risk of pneumothorax and a lower cost. These catheters are widely used in clinical anaesthesia and intensive care medicine in many parts of the developing world. The perioperative indications for PICCs include monitoring central venous pressure (CVP) for fluid management, infusion of caustic drugs and frequent blood sampling. The position of these lines is important, because incorrect placement may be associated with complications such as arrhythmias, thrombosis, phlebitis and cardiac perforation. Moreover, CVP measurement may not be reliable from incorrect placement. The ease of insertion, cost effectiveness, and safety of placement have justified blind PICC insertion without ECG or imaging assistance at bed side in many institutions. This is the method that is followed in our institution in inserting PICCs when indicated for certain elective and emergency procedures.

As a Quality Improvement (QI) exercise, we performed a retrospective audit to assess the tip of PICCs inserted blindly through the antecubital veins. Until now, there is no consensus among clinicians with regard to the location of the tip of central venous catheters (CVCs). To avoid the rare complication of cardiac perforation it has been suggested that the tip of CVCs should be placed above the pericardial reflection. Recent studies have shown that the carina is a
reliable, simple anatomical landmark for the correct placement of CVCs with regard to the pericardial reflection. The purpose of our study was to determine how often correct central placement of PICCs could be achieved in relation to carina as the landmark if it is done blindly without ECG and imaging guidance. We also assessed whether the introduction of digital imaging through Picture Archiving and Communicating System (PACS, GE Health Care) reduced inter-observer variability in reporting of long line position.

Materials and methods
A retrospective study was conducted at the Surgical Intensive Care Unit (SICU) at the Christian Medical College Hospital, Vellore, India from January 2004 to December 2004. Chest radiographs (CXRs) of all patients who got admitted during this period to the SICU were examined. These CXRs were retrieved from the digital imaging using PACS. Admissions included patients from various surgical specialties. Our audit revealed 215 PICCs inserted through the antecubital veins out of 803 consecutive cases. All CXRs were taken as portable supine antero-posterior (AP) CXRs with the cannulated arm in adducted position. A consultant anaesthetist reviewed the first radiograph for each of these long lines inserted and the results were audited.

All cannulations were done in the perioperative period by anaesthetists (trainees as well as consultants) through a large vein in the antecubital fossa. They were done blindly in supine position with the arm in abduction. It was aimed to place the tip of these catheters at the distal superior vena cava (SVC) or at the superior vena cava-right atrial (SVC-RA) junction. This was accomplished roughly by measuring the distance from the insertion site on the arm to the angle of Louie (sternal notch), along the course of the antecubital vein using the stillete and to fix the catheter this distance in the arm. The catheter and the needle systems used in this study included either a 16 gauge catheter with a 14 gauge needle or a 14 gauge catheter with a 12 gauge needle. Single lumen radio opaque polyurethane catheters (with stillete) of two different brands were used (Cavafix 75 cm, B. Braun, Melsungen AG and Vygoflex 75 cm, Vygon GmbH & Co., Aachen, Germany) (Fig. 1).

The location of the tip of PICCs was recorded in relation to the carina. PICC tips were considered as ‘central’ if they resided anywhere within the SVC or at the low SVC-RA junction. Given that the SVC is only 6 cm long and the carina is roughly 3.5 cm higher than the SVC-RA junction, a distance within 30 mm above and 50 mm below the carina was arbitrarily felt to be an acceptable central position (Fig. 2). Various ‘non-central’ tip locations in major veins were also identified. These included innominate (ipsilateral), internal jugular (IJV) (ipsilateral), subclavian, axillary and others (contralateral innominate and subclavian). Tip placements between the medial end of clavicle and up to 30 mm above the carina were considered to be located in the innominate and from the medial end of the clavicle up to the outer border of the first rib were considered to be in the subclavian. All measurements were made using the software available with the PACS system. After performing this
A retrospective audit, the same sets of CXRs with identifiable PICC tip was evaluated for the location of catheter tip by a consultant radiologist. This report was recorded as a second observer. Statistical data were analysed using SPSS package (version 11.0). Categorical variables were assessed by the \( \chi^2 \)-test. Values are expressed as number or percentage (%) as appropriate. Inter-observer variability was assessed by proportion of agreement and by using Cohen’s kappa coefficient as a measure of chance corrected agreement. A kappa value of one would imply complete agreement between both the observers, a value of zero would suggest there was no agreement other than that which would be expected by chance and a value of minus would imply complete disagreement. Interpretation of the coefficient \( \kappa \) is shown in Table 1. Weighted kappa statistics including 95% confidence intervals were used for evaluating inter-observer consistency.

### Results

#### Tip location

Out of the 215 cubital PICCs examined, tips could be identified well in 202 patients. The remaining 13 patients were excluded. There were 138 male and 64 female patients. One hundred and thirty-one PICCs were inserted through the right cubital veins and 71 through the left.

The audit revealed that of 202 PICCs, 75 (37%) had a central catheter tip location in relation to the carina when the first done radiograph was reviewed. This constituted the most common tip position. Concerning the proportion of these PICCs in relation to carina, 30/202 (15%) were located below the carina whereas 45/202 (22%) were located above the carina (Table 2). A high proportion 127/202 (63%) of PICCs had a non-central tip location at various sites (Table 3). The majority of these [57 of 202 (28%)] PICCs had their tips located in the innominate vein which constituted the second most common location.

Regarding the initial PICC tip location 55/131 (42%) of the right-sided catheters had a central location, compared with 20/71 (28%) of the left-sided catheters. There was a near statistically significant difference in the PICC tip location between the sides of insertion \( (P=0.052) \). Concerning the tip placement in central location 45/138 (33%) of PICCs were centrally located in males as compared with 30/64 (47%) in females. This difference was nearly significant \( (P=0.051) \).

A central location was the most frequently located tip position for right-sided catheters whereas the ipsilateral innominate vein was the most common position reported for left-sided catheters (Table 3).

With regard to the proportion of tips in relation to central position, 33 of 131 (25%) PICCs were located above the carina in the case of right-sided catheters while 12 of 71 (17%) were located above the carina in left-sided catheters. In relation to the tips below the carina in centrally located catheters, 22 of 131 (17%) right-sided catheters were located below whereas 8 of 71 (11%) left-sided catheters were located below the carina.

#### Inter-observer agreement

**Agreement in relation to the central location**

There was 92% agreement between the two observers in identifying the tips in relation to the central position (weighted kappa=0.83; 95% CI: 0.75, 0.91) (Table 4).

**Overall agreement**

The two observers agreed on the position in 88% of radiographs with regard to all the locations (weighted kappa=0.87; 95% CI: 0.75, 0.96).

### Discussion

Our study demonstrates that only 37% of the PICCs were sited with their tips in the central location in relation to the carina when inserted blindly. Catheters inserted through the

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**Table 1** Interpretation of the kappa values

<table>
<thead>
<tr>
<th>Kappa value</th>
<th>Strength of agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;0.20</td>
<td>Poor</td>
</tr>
<tr>
<td>0.21–0.40</td>
<td>Fair</td>
</tr>
<tr>
<td>0.41–0.60</td>
<td>Satisfactory</td>
</tr>
<tr>
<td>0.61–0.80</td>
<td>Good</td>
</tr>
<tr>
<td>0.81–1.00</td>
<td>Excellent</td>
</tr>
</tbody>
</table>

**Table 2** The proportion (%) of PICCs at various locations at the central position

<table>
<thead>
<tr>
<th>Location of tip</th>
<th>Right side</th>
<th>Left side</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Within 30 mm from carina (distal SVC)</td>
<td>20 (15.27%)</td>
<td>6 (8.45%)</td>
<td>26 (12.87%)</td>
</tr>
<tr>
<td>Between 30 and 50 mm from carina (SVC-RA junction)</td>
<td>2 (1.53%)</td>
<td>2 (2.82%)</td>
<td>4 (1.98%)</td>
</tr>
<tr>
<td>Within 30 mm above carina (upper SVC)</td>
<td>33 (25.20%)</td>
<td>12 (16.90%)</td>
<td>45 (22.28%)</td>
</tr>
</tbody>
</table>

**Table 3** The locations of PICC tips at various sites, number (%)

<table>
<thead>
<tr>
<th>Location of tip</th>
<th>Right side</th>
<th>Left side</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total n=202</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within 30 mm above and 50 mm below carina (central location)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brachiocephalic</td>
<td>55 (41.98)</td>
<td>20 (28.17)</td>
<td>75 (37.13)</td>
</tr>
<tr>
<td>Subclavian</td>
<td>33 (25.20)</td>
<td>24 (33.80)</td>
<td>57 (28.22)</td>
</tr>
<tr>
<td>Internal jugular</td>
<td>15 (11.45)</td>
<td>15 (21.13)</td>
<td>30 (14.85)</td>
</tr>
<tr>
<td>Right atrium</td>
<td>16 (12.21)</td>
<td>6 (8.45)</td>
<td>22 (10.89)</td>
</tr>
<tr>
<td>Axillary</td>
<td>7 (5.34)</td>
<td>4 (5.63)</td>
<td>11 (5.44)</td>
</tr>
<tr>
<td>Others</td>
<td>4 (3.05)</td>
<td>1 (1.41)</td>
<td>5 (2.47)</td>
</tr>
<tr>
<td>Brachiocephalic (contralateral)</td>
<td>1 (0.76)</td>
<td></td>
<td>1 (0.49)</td>
</tr>
<tr>
<td>Subclavian (contralateral)</td>
<td>1 (0.50)</td>
<td></td>
<td>1 (0.49)</td>
</tr>
</tbody>
</table>
right antecubital veins are more likely to be centrally placed than those inserted through the left. The near statistically significant difference between the two sides in achieving a success rate in central placement may be of clinical significance when choosing the side of insertion. The rates of successful initial central PICC tip placement quoted in the literature varies from 44% to 99%.9–14 The inconsistency in defining ‘central’ among these studies would have contributed to the wide variation in initial success rates.9–14 Controversy still exists regarding the optimal location of CVC tips. For temporary central venous catheters such as PICCs, the optimal position recommended is the distal SVC.15 Low SVC or upper right atrium has been suggested as a suitable tip site for CVCs from any access point in the upper body.15 However, it is difficult to appreciate the SVC-RA junction in the standard AP chest radiograph. It has also been proposed that the tip of CVC has to be placed above the carina to avoid the rare but fatal complication of cardiac tamponade. But other risks and complications resulting from higher placement also should be considered. Hence, unsatisfactory tip position above the heart should not be accepted purely to satisfy the guideline of preventing cardiac perforation. Therefore, it is recommended that the catheter tip should be placed in as large a vein as possible, ideally outside the heart and lie in the long axis of the vein such that the tip does not abut the vein or heart wall end-on.16 Based on these, more recent guidelines suggest that left-sided catheters are safe if placed below the carina and right-sided catheters are to be sited above the carina in the central location at long axis to SVC.17 Overall 30 of 202 (15%) of the PICCs were located below the carina. This proportion is much less when compared with the number of CVCs inserted through the neck veins reaching below the carina. In a recently published study it was found that 38% of CVCs inserted through neck veins reached below the carina.17 Thus there may be a tendency to limit the insertion of antecubital PICCs. Left-sided PICCs are less likely to be placed below the carina—only 11% in this audit. This is almost consistent with the report by Stone-lake and Bodenham where they found that 14% of left-sided CVCs inserted through neck veins were below the carina.17 It is evident from these observations that left-sided PICCs are less likely to reach the central position. It may be attributed to the greater distance traversed by left-sided catheters in reaching SVC.

In our study, though a central location was the most common tip position for right-sided PICCs, the innominate vein (ipsilateral) was the commonest location for left-sided ones. Since the left innominate vein is 3.5 cm longer than the right (6 cm vs 2.5 cm), left-sided catheters needed to be pushed in further to aim for a central location and more so for locations below the carina. Catheter tips entering only a short distance into the right atrium are probably not associated with increased rates of morbidity and mortality.18 In addition, catheters will generally function equally well for pressure measurement and fluid infusion if the tip is situated in any major vein above or below the heart.16 Venous pressure measured in any of the intrathoracic veins will reflect right atrial pressure within 1.0 mm Hg in the supine individual.19 Central location and innominate placement accounted for 65% of our PICCs. This would suffice in the perioperative setting for reliable CVP monitoring and fluid therapy.

Inter-observer variability must be taken into account in the interpretation of any radiographic investigation. Assessment of catheter tip position with plain chest radiography is often inaccurate and subject to inter-observer variability.15 The kappa coefficient in this study has been used as a way to quantify the level of agreement, while correcting for chance. Using these criteria there was excellent agreement on locating the tip of PICCs with the use of PACS. There was >80% agreement between the observers in locating the tip at all locations as well as at the central location. The kappa values obtained in our study differ greatly from values reported in other studies looking at inter-observer variability on chest radiography for diagnosis of other pathologies using PACS. The kappa values reported in those studies ranged from 0.29 to 0.51 which correlated with fair to satisfactory agreement.20,21 This greater discrepancy is probably because of the increased digital manipulations available in locating the tip of CVCs when compared with the manipulations that can be done for pathological lesions. The subjective accuracy in locating the long lines rather than an objective assessment of pathological lesions may be a considerable factor contributing to a low inter-observer variability. Moreover, kappa is likely to be affected by the prevalence of the finding under consideration much similar to how predictive values are affected by the prevalence of the disease under consideration. It was able to accurately locate the tip in 94% (202/215) of the long lines. With the digital technique of image inversion together with image magnification and sharpening, the tips of long lines can be better appreciated than on plain X-rays. Accurate measurements of distances between any two landmarks on the image can be easily made using the software.

Eleven per cent (22 of 202) of our PICCs were located in the ipsilateral internal jugular vein (IJV) which is lower than the incidences quoted in other studies. An 18% incidence of PICCs entering the IJV has been reported in two different studies by Ragasa and coworkers14 and Burgess and colleagues.22 The same incidence quoted in the paediatric population ranges between 14%23 and 37%.24 A neck compression test has been recommended by Lumley and Russell to detect IJV placement.25 Neck compression produces a

<table>
<thead>
<tr>
<th>Tip location</th>
<th>Weighted kappa value (95% CI)</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>All locations</td>
<td>0.87 (0.75, 0.96)</td>
<td>Excellent</td>
</tr>
<tr>
<td>Central locations</td>
<td>0.83 (0.75, 0.91)</td>
<td>Excellent</td>
</tr>
</tbody>
</table>
rise of more than 10 cm H2O in the recorded venous pressure after inadvertent internal jugular catheterization, whereas no such rise occurs when the other side of the neck is compressed.

Different manoeuvres have been suggested to improve the success rate of PICC insertion in the absence of ECG and imaging guidance. Turning the patient’s head towards the side of cannulation and applying digital pressure over the ipsilateral supraclavicular fossa increases the success rate by 78%. This manoeuvre if combined with the technique of removing the stillete and injecting 5–10 ml of physiological saline solution while the catheter enters the axillary venous plexus results in a 90% success rate in PICC placement. Various guided techniques such as J wire guidance and fluoroscopic guidance have also been advocated to improve the success rate.

Significant proportions [127 of 202 (63%)] of our catheter tips lie in a suboptimal position. These positions are probably clinically acceptable for short-term CVP monitoring and isotonic fluid infusions. However, these locations are unacceptable for long-term use particularly for the infusion of vasopressors, total parenteral nutrition, chemotherapy drugs etc. These misplaced catheters should be handled appropriately depending upon the indications of insertion. Although we did not look in to how these catheters were dealt with, some of the options are to remove, resite with screening under aseptic conditions, or accept short term.

Our study had several limitations: measurement of the angle made by the PICC tip to the vessel wall which was possible with the available software was not done in our study. We did not categorize the experience of the anaesthetist who sited these lines. Besides, we did not look into the type of cubital vein that was chosen, either basilic or cephalic. But it should be remembered that the failure rate is high when cephalic vein is chosen for insertion. Furthermore, the catheters were not the same for the duration of the study period. A randomized study using a standard catheter comprising four different antecubital veins namely right cephalic, right basilic, left cephalic and left basilic would give more meaningful data.

We conclude that when done blindly, PICCs inserted through the right antecubital veins are more often placed in a central location in relation to the carina when compared with those inserted through the left antecubital veins. Left-sided PICCs need to be sited at a further depth than compared with right-sided PICCs to aim for a more central location and to avoid innominate vein placement. Whenever possible, right cubital veins have to be chosen for PICC placement as the success rate for a central location in relation to carina is high. If the patient’s clinical condition warrants an exact central localization of the tip, it is mandatory to insert these catheters with imaging guidance to ensure correct position as misplacement is very common.

Digital imaging is an incredible tool in interpreting the position of PICCs inserted through antecubital veins. This technology is accurate and reliable in diagnosing the malpositioning of PICCs.

Acknowledgement
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