

Bedside prediction of the central venous catheter insertion depth

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Background. The carina level has been shown to be near the pericardial reflection and can easily be identified as a landmark on a routine chest radiography. The purpose of this study was to reveal a simple method to predict the adequate central venous catheter (CVC) depth, hereby facilitating safe positioning of the CVC tip.

Methods. Central venous catheterization was performed via the right internal jugular vein (IJV) or the right subclavian vein (SCV). The CVC was placed at a depth derived by adding the length between the needle insertion point and the clavicular notch and the vertical length between the clavicular notch and the carina on the chest radiograph. The distance between the CVC tip and the carina was measured on the postoperative chest radiograph.

Results. The tip position of 100 CVCs placed via the right IJV was 0.1 (1.1) cm [mean (sd)] below the carina (95% CI: 0.3 cm below carina–0.2 cm above carina) and the tip position of 153 CVCs placed via the right SCV was 0.0 (1.2) cm [mean (sd)] below the carina (95% CI: 0.2 cm below carina–0.2 cm above carina). There were nine outliers (two in IJV group and seven in SCV group).

Conclusions. When CVCs are inserted to a depth derived by adding the length between the needle insertion point and the clavicular notch and the vertical length between the clavicular notch and the carina, the CVC tip can be reliably placed near the carina level.

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Landmarks,^{1–3} simple formulas,^{4–5} and sophisticated techniques such as right atrial (RA) electrocardiography^{6–7} and transoesophageal echocardiography^{7–8} have been proposed for positioning the central venous catheter (CVC) to an adequate depth in adults. To minimize the risk of cardiac tamponade, it has been suggested that the CVC tip should be located above the cephalic limit of the pericardial reflection, not merely above the superior vena cava–RA junction.⁹ Of the landmarks easily identifiable on a routine chest radiograph (CRX), the level of the carina has been shown to be near the level of the pericardial reflection in fresh and preserved cadavers and in computerized tomography studies of adult patients.^{1–3, 10} The carina has since been studied as an attractive target level for CVC tip position.^{1–3}

In order to determine the depth of CVC insertion using the carina as a reference point, a landmark identifiable both superficially and on the CRX may be helpful. The clavicular notch described by Rao *et al.*¹¹ can be

consistently palpated 0.25–1 cm lateral to the sternal head of the clavicle on the superior surface of the clavicle and easily identified on the CRX. In addition, the right brachiocephalic vein, tributaries of which are the right internal jugular vein (IJV) and the right subclavian vein (SCV), lies beneath this clavicular notch.¹² Thus, the course of the CVC placed via the right IJV or the right SCV runs under this clavicular notch.

The purpose of this study was to devise a simple formula (1) that can predict CVC depth using the carina and the clavicular notch as landmarks and (2) that accounts for variable skin puncture sites depending on the practitioner and the different bodily lengths of patients.

Methods

After having obtained IRB approval and patients' informed consent, 267 patients scheduled for either neurosurgery or

thoracic surgery requiring central venous catheterization were enrolled. The right IJV ($n=102$) was catheterized in patients undergoing lung surgery and the right SCV ($n=165$) was catheterized in patients undergoing neurosurgery, oesophageal surgery, or other thoracic surgeries.

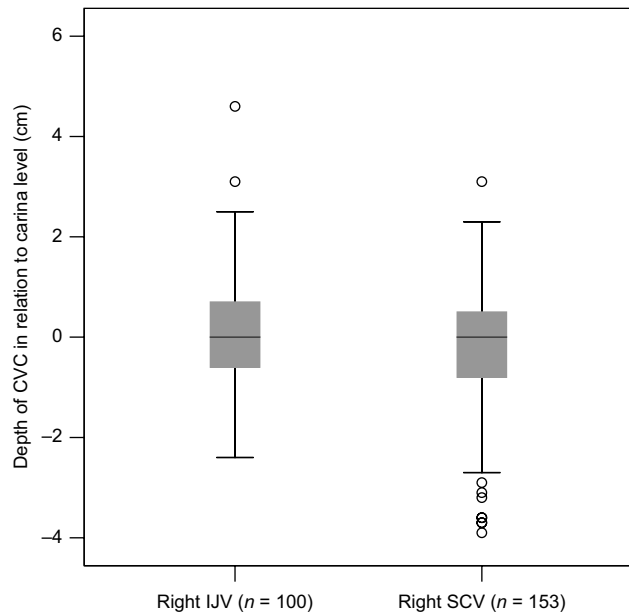
After antiseptic preparation and draping, central venous catheterization was performed using a double lumen CVC (Arrow International Inc., Reading, PA, USA). The anterior approach, using the sternocleidomastoid muscle as a landmark, was used for right IJV catheterization and the infraclavicular approach was used for right SCV catheterization. The patient's head and neck was placed in the neutral position after the insertion of the guidewire. The shortest straight length between the insertion point of the needle and the clavicular notch of the right clavicle was measured using a sterile disposable paper ruler. Prior to CVC placement, the vertical distance between the clavicular notch of the right clavicle and the carina was measured on the preoperative posterior-anterior CRX using the internal measuring tool available on the hospital's picture archiving communication system. The CVC was inserted and secured to a depth determined by adding the two measurements (length between skin insertion point and clavicular notch + vertical distance between clavicular notch and carina). The vertical distance between the CVC tip and the carina was measured on the immediate post-operative CRX obtained during inspiration. CVC tips positioned above the carina level were presented in positive values and below the carina in negative values.

A *t*-test was performed for statistical analysis using the SPSS for Windows version 12.0 (SPSS, Chicago, IL, USA). A *P*-value of <0.05 was considered to be statistically significant.

Results

Patient characteristics are described in Table 1. Two attempts of CVC insertion via the right IJV and 12 attempts via the right SCV resulted in catheterization failure or catheter malposition and were excluded from data analysis.

The CVC tip position of 100 CVCs placed via the right IJV was 0.1 (1.1) cm [mean (SD)] ($P=0.517$) below the carina (95% CI; 0.3 cm below carina–0.2 cm above carina) and the tip position of 153 CVCs placed via the right SCV



CRX to confirm the CVC tip position. Moreover, variability in needle insertion points and also in patients' bodily lengths is a fact. As such, a formula for predicting optimal CVC depth should thus consider insertion point variation, patient's body size, and radiological and physical landmarks simultaneously.

The parallax effect, which describes augmentation of structures located anteriorly or posteriorly and peripherally, should be considered when using the CRX for measurements. Compared with the routine posterior–anterior CRX, the effect is greater and more variable with the portable anterior–posterior CRX used in the intensive care unit or the operating theatre. In this regard, the carina, being located in the centre of the thorax, has less potential for image distortion and measurement error.

A study suggested that it was safe to omit routine CRX after uncomplicated insertion of CVC through the right IJV¹⁴ and a survey of anaesthetists in the UK revealed that nearly half of the respondents did not order CRXs after CVC insertion unless specifically indicated.¹⁵ However, many institutions have protocols that require radiological confirmation of the CVC position prior to its use. Adjusting the depth of the CVC postoperatively on the basis of the CRX can be a cumbersome procedure and has the potential to become a source of infection, especially when the catheter needs to be advanced.

The outliers found in our study reflect one of the limitations of our study. The parallax effect described above may have exaggerated the outliers away from its actual position. There is also the potential that the portable X-ray beam angle may have been inconsistent resulting in a further exaggeration of peripherally located CVC tips. Another limitation that should be considered is that only right-sided CVC tip positions were investigated. Further investigation is warranted for bedside prediction of left-sided CVC tip positions.

Although the optimal CVC tip position may differ depending on its intended use and the catheterization site, the optimal position of the CVC tip is still under controversy and it is up to the individual practitioner to decide where the CVC tip should be. Moreover, the relationship between the pericardial reflection and the carina is not known in the individual patient. Nonetheless, the results of our study may help predict the right-sided CVC tip position at the bedside.

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References

- Schuster M, Nave H, Piepenbrock S, Pabst R, Panning B. The carina as a landmark in central venous catheter placement. *Br J Anaesth* 2000; **85**: 192–4
- Stonelake PA, Bodenham AR. The carina as a radiological landmark for central venous catheter tip position. *Br J Anaesth* 2006; **96**: 335–40
- Albrecht K, Nave H, Breitmeier D, Panning B, Tröger HD. Applied anatomy of the superior vena cava – the carina as a landmark to guide central venous catheter placement. *Br J Anaesth* 2004; **92**: 75–7
- Chalkiadis GA, Gouke CR. Depth of central venous catheter insertion in adults: An audit and assessment of a technique to improve tip position. *Anaesth Intensive Care* 1998; **26**: 61–6
- Peres PW. Positioning central venous catheters—a prospective survey. *Anaesth Intensive Care* 1990; **18**: 536–9
- Wilson RG, Gaer JA. Right atrial electrocardiography in placement of central venous catheters. *Lancet* 1988; **27**: 462–3
- Jeon Y, Ryu HG, Yoon SZ, Kim JH, Bahk JH. Transesophageal echocardiographic evaluation of ECG-guided central venous catheter placement. *Can J Anesth* 2006; **53**: 978–83
- Andropoulos DB, Stayer SA, Bent ST, Campos CJ. A controlled study of transesophageal echocardiography to guide central venous catheter placement in congenital heart surgery patients. *Anesth Analg* 1999; **89**: 65–70
- Collier PE, Blocker SH, Graff DM, Doyle P. Cardiac tamponade from central venous catheters. *Am J Surg* 1998; **176**: 212–4
- Caruso LJ, Gravenstein N, Layon AJ, Peters K, Gabrielli A. A better landmark for positioning a central venous catheter. *J Clin Monit Comput* 2002; **17**: 331–4
- Rao TLK, Wong AY, Salem MR. A new approach to percutaneous catheterization of the internal jugular vein. *Anesthesiology* 1977; **46**: 362–4
- Cardiovascular system. In: Williams PL, ed. *Gray's Anatomy*, 38th Edn. New York: Churchill Livingstone, 1995; 1589–90
- Czepizak CA, O'Callaghan JM, Venus B. Evaluation of formulas for optimal positioning of central venous catheters. *Chest* 1995; **107**: 1662–4
- Lessnau KD. Is chest radiography necessary after uncomplicated insertion of a triple-lumen catheter in the right internal jugular vein, using the anterior approach? *Chest* 2005; **127**: 220–3
- Mills SJ, Tomlinson AA. The use of central venous cannulae in neuroanaesthesia: A survey of current practice in the UK. *Anaesthesia* 2001; **56**: 465–9