A New Formula to Estimate the Length of Right Upper Extremity Vein from Elbow Crease to Carina Calculated by Peripherally Inserted Central Catheter Insertion through Right Basilic Vein Puncture

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Purpose: To measure the length of the upper extremity vein between the elbow crease and the carina (elbow crease to carina length, ECL), to facilitate the appropriate positioning of the tip of the peripherally inserted central catheter (PICC).

Materials and Methods: A total of 124 patients (64 men and 60 women; mean age 65.2 ± 15.4 years; range, 21-90 years) inserted with PICC through the right basilic vein under fluoroscopy were included in this retrospective study. The ECL was determined as follows: ECL = (distance from elbow crease to puncture site) + (the catheter length of PICC) - (distance from carina to catheter tip on post-procedural chest radiograph). We analyzed the relationship between ECL and patient height.

Results: The mean ECL through right basilic vein was 42.07 ± 4.03 cm (27.5 to 52.2 cm). ECL was found to be significantly correlated with patient height: ECL (cm) = 0.24 × patient height (cm) + 3.75.

Conclusion: The formula developed in our study would be helpful for predicting the optimal catheter length during a blind bedside procedure of PICC via the right basilic vein.

INTRODUCTION

Since the first attempt to use upper extremity veins to access the central venous system in 1912, peripherally inserted central catheter (PICC) has become more popular primarily for the infusion of antineoplastic agents, fluid replacement, long-term parenteral nutrition, as well as monitoring central venous pressure (1-3). Although PICCs play an essential role in the care of critically ill patients, they are associated with serious complications such as arrhythmia, thrombosis, phlebitis, and cardiac perforations. For proper monitoring of central venous pressure and a decrease of the risk of complications, it is mandatory to achieve appropriate catheter tip position (4-6).

Currently, PICCs are frequently inserted at the patient’s bedside blindly (without fluoroscopic guidance), followed by chest radiographic confirmation of correct catheter tip position. In that situation, it would be useful for the adequate catheter tip placement to estimate the length of the upper extremity vein prior to the PICC procedure by considering a patient’s characteristics such as height. To our knowledge, however, there has been no published article concerning the direct measurement of upper extremity vein length for appropriate positioning of the PICCs.
The aim of this study is 1) to measure the length of upper extremity vein from the elbow crease to the carina (elbow crease to carina length, ECL) and 2) to devise a simple formula for ECL using patient height, which could predict the optimal length of the PICC.

MATERIALS AND METHODS

Study Population
This retrospective study was performed in 188 consecutive Korean adult patients who received right-side PICC insertion from April 2008 to December 2010. Our institutional review board approved this study with a waiver of informed consent and the procedures performed were in accordance with the ethical standards of the World Medical Association (Declaration of Helsinki). Of these, 64 patients were excluded from our study for the following reasons: 1) PICC insertion through a vein other than the right basilic vein (e.g., the right brachial or cephalic vein) \( (n = 41) \), 2) incomplete record of patient height or length of PICC on the hospital information system \( (n = 19) \), and 3) mediastinal shift due to pneumonectomy or atelectasis \( (n = 4) \). The final study group consisted of 124 patients, including 64 men and 60 women (mean age 65.2 ± 15.4 years; range, 21-90 years). Patient height recorded on the hospital medical information system ranges from 140 to 180 cm with a mean (± standard deviation) of 160.8 ± 9.7 cm.

PICC Procedure
For all patients, PICC insertion through the right basilic vein was done with the patient supine on the table in the angiography suite. During the procedure, the elbow joint was fully extended and the arm was externally rotated as much as possible and abducted about 40 degrees. Under ultrasonography guidance, vein puncture was done proximal to the elbow crease with a micro-puncture needle in the PICC set (5 Fr. Turbo-flo, Cook Medical Inc., Bloomington, IN, USA). After insertion of the calibrated guidewire with the tip at the level of carina and dilatation of the cutaneous tract, the catheter was cut according to the length estimated by the guidewire inside the body (from the puncture point to the level of inferior margin of carina under fluoroscopy). Then, PICC was inserted along the guidewire as deep as possible and the external portal of the catheter from skin was fixed with a fixation device in the PICC set.

Data Analysis
The ECL in each patient was defined as follows: 
\[ \text{ECL} = (\text{distance from elbow crease to puncture point}) + (\text{the catheter length of PICC inside the body}) - (\text{distance from the carina to the catheter tip on post-procedural chest radiograph}). \]
The distance from the elbow crease to the puncture point of the skin and catheter length inside the body were measured and recorded by one of the interventional radiologists (E.Y.J., S.Y.C.), who performed the PICC insertion. The distance from the carina to the catheter tip was measured on the post-procedural antero-posterior chest radiograph using the software available with the PACS system. If the location of the catheter tip was not clearly visible on the post-procedural chest radiograph, a new antero-posterior chest radiograph was requested. All films were read by an interventional radiologist (E.Y.J.), who was unaware of the radiology report and patient height.

Descriptive statistics were expressed as the mean ± standard deviation. A linear regression analysis was performed to identify the relationship between ECL and patient height.

RESULTS
In 124 patients in whom the right basilic vein was punctured during the PICC procedure, the mean distance from elbow crease to puncture point of the skin was 4.42 ± 1.45 cm (1 to 9 cm), the mean catheter length inside the body was 41.91 ± 3.58 cm (29 to 52 cm), and the mean distance from the carina to the catheter tip was 4.27 ± 2.77 cm (-2.8 to 11 cm). The calculated measurement of ECL through the right basilic vein was 42.07 ± 4.03 cm (27.5 to 52.2 cm).

According to the results of the linear regression analysis, there was a statistically significant correlation \( (p < 0.01) \) between ECL and patient height. The ECL through right basilic vein could be estimated by using the following formula: 
\[ \text{ECL (cm)} = 0.24 \times \text{patient height (cm)} + 3.75 \] (Fig. 1).

DISCUSSION
The optimal position of the central venous catheter tip is still under controversy. However, the literature does agree that cen-
entral venous catheter tips should be placed at the junction of the superior vena cava (SVC) and the right atrium (RA), or in the distal SVC (7, 8). A post-procedural chest radiograph, usually a portable supine chest radiograph, is known as the most effective method to confirm appropriate positioning of the catheter tip (9-12). The SVC-RA junction cannot be reliably identified from a plain chest radiograph, but it is generally accepted to be always located below the carina (9, 10). Therefore, recent studies have recommended that the carina has been recommended as a landmark for guidance in central venous catheter placement (11, 12). In this study, we considered the carina as a radiological landmark for PICC tip position.

Although there are several advantages to placing PICCs in an interventional radiology suite with fluoroscopic guidance, blind insertion of PICCs at the patient’s bedside is necessary in many instances and sometimes inevitable. In the literature about blind insertion of PICCs, rates for successful initial central PICC tip placement ranged from 37% to 99% (6, 13-15). The inconsistency in defining ‘central’ among these studies would likely have contributed to this wide variation in success rates. The initial successful placement of the PICC by a simple bedside technique is important, because incorrect placement may have required several manipulations and multiple chest radiographs, hence delaying treatment. Therefore, it would be desirable to estimate the expected catheter length for PICC insertion.

Various maneuvers such as digital pressure over the ipsilateral supraclavicular fossa and head turning toward the side of cannulation have been recommended to improve the success rates of blind PICC insertion (16). To our knowledge, there have been a few formulae or methods to predict ‘the optimal length of insertion’ of the PICC at the bedside. Although there is documentation about the length of upper extremity veins including cephalic, basilic, axillary, subclavian, and innominate veins as well as superior vena cava, those are mostly for the average-sized adults (5, 17). Lum’s measurement guide for central venous catheter suggested the length of both upper extremities for PICC in relation to patient height, but was based on the anatomical correlation of the lengths of the humerus and clavicle with upper extremity veins (18).

In this study, ECL was calculated based on the direct transvenous measurement and was significantly correlated with patient height. We could obtain a formula of ECL (3.75 plus 0.24 by height) and estimate the length of right upper extremity vein by simply using patient height. So, we believe that our formula could be more accurate and practical. There is somewhat a wide variation in the calculated ECL in specific patient height on the scatter plot (Fig. 1). This wide variation may be partially explained by possible error in the height measurement, especially in elderly or bed-ridden patients, and a length marker interval of 5 cm (not 1 cm) for the guidewire in the PICC set. The ECL from patient height can be useful in the application during the PICC procedure, as the length from the elbow crease to the puncture point is the length from the carina to the catheter tip past the carina. We are applying this equation on every PICC procedure with the catheter cut according to the ECL from patient height because we usually puncture the basilic vein about 3 cm above elbow crease in trying to locate the catheter tip 3 cm past the carina. It is useful especially when the guidewire is not smoothly inserted to the superior vena cava level due to stiffness or kinking of the guidewire and the catheter, and the guidewire should be combined in negotiating the right path along axillary, subclavian, or innominate vein because the measurement with calibrated guidewire is impossible in those cases.

There are several limitations to our study. First, all PICCs were placed through the right-sided vein. The right-sided vein is used more frequently than the left-sided vein as the access vessel for PICC placement and the success rate for a central lo-
cation is high. Because of the limited number of patients who underwent PICC insertion via left-sided veins, we did not include left-sided catheterization. One would expect that a longer pathway of PICCs in left side insertions, compared to right side insertions; hence, a similar investigation is required for bedside prediction of left-sided ECL. Second, the formula for predicting optimal length of ECL should consider many variables such as the site of insertion, patient height and body habitus (19). We chose patient height and created a simple formula to determine optimal catheter placement according to the regression line; body habitus (e.g., obesity) was not tested in this study. Although we believe that our guide may be practical, more patient variables other than height should be considered in future studies. Finally, there may be racial differences in the length of the upper extremity vein but this could not be determined in our study because all our patients were Korean.

In conclusion, the length derived from a simple formula based on patient height [ECL (cm) = 0.24 × patient height (cm) + 3.75] could be used as a guideline for insertion length for PICC when catheters were placed through the right basilic vein.

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우측 척측 피정맥을 통해 삽입한 말초삽입중앙정맥관 길이에서 예측한 우측 상지 정맥 길이: 새로운 공식

조현환1·전의용1·이현정1·이현1·고성혜1·최선영1·이관섭1·윤대영2·임형준3

목적: 말초삽입중앙정맥관(이하 PICC)의 끝을 정확하게 중심정맥에 위치시키는 데 도움을 줄 수 있도록, 우측 주관절과에서 기관 분기부까지의 우측 상지 정맥의 길이(elbow crease to carina length: 이하 ECL)를 측정할 수 있는 공식을 제시하고자 하였다.

대상과 방법: 우측 척피 정맥을 통해 투시하에 PICC를 설치한 124명의 환자(남자 64명, 여자 60명; 평균 나이 65.2 ± 15.4세; 범위 21~90)에서 ECL = (주관절와에서 천자부위까지의 거리) + (몸 안의 PICC관 길이) - (시술 후 방사선 사진에서 측정한 기관 분기부에서 PICC 끝까지의 길이)를 계산하여 환자의 키와 ECL과의 상관관계를 분석하였다.

결과: ECL의 평균은 42.07 ± 4.03 cm(27.5 to 52.2 cm)였고, ECL은 환자의 키와 통계적으로 의미 있는 상관관계를 보였으며 공식은 ECL (cm) = 0.24 × patient height (cm) + 3.75였다.

결론: 본 연구를 통해 얻은 공식은 우측 척피 정맥을 통해 시행하는 PICC 시술 동안 PICC관 길이를 예측하는 데 도움이 될 것이다.

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