# Successfully Eliminating Chest Radiography by Replacing It With Dual Vector Technology and an Algorithm for PICC Placement

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## Abstract

*It can be difficult to get the tip of a central vascular access device to the targeted area of the caval-atrial junction accurately and precisely when placing a device at the bedside. Tip placement outside this precise location can lead to complications and poor patient outcomes. Malpositions increase patients' radiation exposure, increase costs, and delay treatment. The current standard of using chest radiography to check tip placement has demonstrated discrepancies and is subject to interpretation differences between radiologists. Chest radiography and malpositions can be eliminated with the use of technology that includes Doppler, echocardiography (ECG), and an algorithm. This technology can reduce the cost of labor and supplies in addition to allowing the use of a central vascular access device immediately after placement.*
***Keywords:*** *chest radiograph, peripherally inserted central catheter, intravascular Doppler, caval-atrial junction, superior vena cava, ECG*

## Background

Patients rely on vascular access specialists (VASs) to precisely place peripherally inserted central catheters (PICCs) to decrease complications and improve outcomes. Many VASs place PICCs blind using external measurements. Placing PICCs in this manner can lead to malpositions and in many cases leaves the PICC in a suboptimal position. The current standard for tip placement of a PICC is the lower one-third of the superior vena cava (SVC) at the caval-atrial junction (CAJ).[1,2] Currently the gold standard for tip confirmation—the chest radiograph (CXR)—has limitations.[3] The need to get central venous access devices to this targeted location on the first attempt is crucial for good patient outcomes related to vascular access. The current standard creates delays in care due to the need to wait for the CXR to be taken, read, and dictated. This delay can be increased further by malpositions. Improper tip placement can be time-consuming and frustrating for the inserter and the patient receiving the device. This can mean the tip is placed in the right atrium, the azygos vein, the internal jugular vein, or contralaterally. These types of malpositions can sometimes be repositioned by retracting the device or by vigorously flushing with saline using a 10-mL syringe in an attempt to get the tip to drop into the SVC. After repositioning, another CXR is required to confirm that optimal tip position has been achieved. In some cases, such when the catheter coils in the subclavian vein, an exchange may be indicated. This is a more complex procedure that incurs more costs, time, delays, and risks to patients. In some of these cases after failed attempts at the bedside to adjust the PICC, a patient may need to be referred to interventional radiology, causing more delays and costs. This may diminish a patient's trust.

### *Literature Review*

There is a great deal of discussion in the literature concerning proper tip location to decrease catheter-related complications. Catheters that are placed proximal to the lower one-third of the SVC are 16 times more likely to experience thrombus formation compared with those at the lower one-third of the SVC or at the CAJ.[4] Our study demonstrated that proper tip placement in the lower one-third of the SVC or at the CAJ can positively influence patient outcomes and decrease complications related to tip placement. Electrocardiography (EKG) has been used in Europe for decades with success. Pittiruti et al[4] looked at the advantages, cost-effectiveness, and feasibility of using EKG to determine

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appropriate tip location and found that PICCs placed using EKG technology were placed in the lower one-third of the SVC or at the CAJ, and those placed without the technology had a higher incident of malposition. It was concluded that the use of EKG may strongly improve cost-effectiveness and safety while ensuring proper tip placement. The disadvantage of EKG technology is that it cannot be used in patients with the absence of a P wave or atrial fibrillation, such as in atrial arrhythmias. EKG technology requires a basic understanding of EKG reading and the interpretation of an inverted P wave. The advantages of using EKG technology include a safe, simple, accurate, and noninvasive method of tip confirmation. This method allows for definitive information about the tip position during placement and reduces radiation exposure and the costs associated with radiograph and malpositions.

Advancing a catheter tip to the targeted zone can be difficult in some patients. According to Cadman et al,[5] the average length of an adult SVC is 7.6 cm with a range of 5.0-10.5 cm. With the targeted tip location in the lower one-third of the SVC, the average target for the tip of the catheter is 2.5 cm. This can vary based on a patient's height and anatomy, making landmark measurement inconsistent and unreliable. The Food and Drug Administration (FDA) clearly states that the tip of a catheter should not be allowed to migrate into the heart.[6] Vascular Positioning System (VPS) technology (VasoNova Inc, Menlo Park, CA) combines the ECG with intravascular Doppler and algorithm logic to compute the position and direction of a catheter tip in real time. Combining these technologies allows the VPS to analyze the internal information of each individual patient to identify the lower one-third of the SVC.

## Methods

Our study was conducted at a 480-bed community hospital located 45 miles southwest of Chicago. The hospital is a level-III trauma center and has a large cardiology and neurology populations. The vascular access team at this institution has grown from placing 350 PICCs annually to approximately 1,000 PICCs annually using ultrasound guidance at the bedside. The team consists of 1.4 full-time employees who place PICCs Monday-Friday, 8 am-4 pm.

A number of factors influenced the vascular access team's decision to evaluate the efficacy of the VPS with patients who require PICCs. First, the VPS is a new tip confirmation technology that is approved by the FDA for PICC and central venous catheter (CVC) placement. Second, the technology uses ECG, intravascular Doppler, and algorithm logic to eliminate CXR after the placement of CVCs. Third, attending a conference where this technology was demonstrated also influenced the decision to further study the VPS technology. Finally, after conducting a literature review to explore eliminating CXR, the vascular access team designed a study to evaluate the efficacy of VPS in patients who require a PICC.

### *Study Design*

A quantitative, prospective, nonrandomized study was conducted over 12 days. The sample consisted of 31 patients hospitalized at a midwestern medical center; however, based on the total number of PICCs inserted at this facility, the sample allowed for a 99% confidence level that the results would not be by chance. Although the sample was 1 of convenience, it still provided relevant information to this facility that allowed improvement of the standard of care. This sample size was modeled after a 2011 study by Costantino et al.[7] In that study, the sample size was 81 patients and a 98.4% success rate was achieved using VPS. Therefore, a 98% success rate was hypothesized for our study. The data for our study were collected using the PICC Registry.[8]

After institutional review board approval was obtained, the study population was selected from the patient population at a midsized medical center in the Midwest. Patients enrolled in the study had to meet standard criteria for a PICC insertion at the facility. Inclusion criteria included long-term antibiotics use; poor venous access; the need for total parenteral nutrition; and patients in the critical care area requiring multiple infusions, including vesicants. Per the facility's standard of care, the exclusion criteria included patients with compromised arms (including deep vein thrombosis), lymph node dissection, and end-stage renal disease.

## Results

Our study enrolled 31 patients. Twenty-five patients had normal sinus rhythm. ECG indicated an elevated P wave; the Doppler scan demonstrated a mirror image and the algorithm logic indicated a blue bull's eye 25 times, thus achieving 100% accuracy in patients with normal sinus rhythm, when compared with CXR (see Figure 1). This mirrored the study by Costantino et al.[7] An unexpected outcome was found with 5 patients diagnosed with atrial fibrillation (see Figure 2). Three of 5 patients achieved a blue bull's eye, suggesting that the dual vector and algorithm technology may be useful in patient populations that do not have a normal sinus rhythm. This is an area of further study that should be explored. One patient was dropped from the study due to technical difficulties with the device that caused a high level of anxiety for the patient.

### *Limitations*

The small sample size was a limitation of our study noted by the principal investigator at the onset. It was identified that the sample size studied may not be comparable to the other patient populations, and therefore, may not be generalizable. The principal investigator also noted that this lack of potential generalizability could lead to lower external validity of the study. The study was nonrandomized; therefore, it is subject to selection bias, which could have a confounding effect on comparisons between the historical PICC population at the medical center (830 in 2011) and the patients enrolled in our study (31 in 2012). This could limit the effect of the intervention; for example, a larger sample size may not achieve 100% correlation. It could also increase the variability of the observed effect. The assumption is that the sample size and methods used for our study would provide meaningful information that could benefit the patients at the medical center included in this study.