

ECG method for positioning the tip of peripherally inserted central catheters in patients with atrial fibrillation

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Funding information

Fund: Hebei Province Medical Science Research Key Project Plan, Project Code: 20150165, Project name "Clinical Study of the Location of PICC catheter"

Abstract

Objective: To observe the changes of F waves on electrocardiograms (ECGs) in patients with persistent atrial fibrillation during the insertion of a peripherally inserted central catheter (PICC), and to analyze the application effect of the ECG method (through F wave changes) for guiding PICC tip positioning.

Methods: Seventy-two patients who met the inclusion criteria and needed a PICC catheter were selected as the research subjects. We observed waveforms in the ECGs when the tip of the catheter reached a predetermined position. The chest X-ray results were used as the gold standard to calculate the sensitivity and specificity, and judge the safety and accuracy of ECG-guided PICC tip positioning in patients with atrial fibrillation.

Results: Of the 72 patients, there was no significant difference between the ECG method and chest X-ray results ($\chi^2 = 0.2, p > 0.05$). Sixty-one patients had F wave changes on ECG and 10 had no obvious changes (X-ray results confirmed that five patients had a tip position that was too shallow, two had ectopic tip positions, and three were located in the correct place). The sensitivity of the method was 95.7% and the specificity was 80%.

Conclusion: As the ECG baselines of patients with persistent atrial fibrillation were difficult to judge and the F wave was irregular, we found that the F wave was significantly higher than before catheter insertion and fell back while withdrawing the catheter, so the catheter should be fed until the F wave significantly increased as the correct position of the catheter tip.

KEYWORDS

atrial fibrillation, electrocardiogram, patients, PICC, tip positioning

1 | INTRODUCTION

A peripherally inserted central catheter (PICC) has been widely used in clinical intravenous therapy with elevated safety, fewer complications, and long indwelling time. The globally recognized "gold standard" for PICC catheter tip positioning is based on chest X-ray

results. Most patients with atrial fibrillation are older patients (Nan & Yang, 2015) who may have multiple complications and limited mobility resulting in lying in bed long-term. X-ray positioning is not timely for PICC tip positioning for patients with atrial fibrillation. The bedside chest X-rays are sometimes not clear, which affects judgment, and they can cause specific radiation damage to the human body.

Conghui Zhao and Yuxin Zhu contributed equally to this study.

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In recent years, domestic and foreign researchers have used electrocardiography (ECG) localization technology to locate the position of the PICC catheter tip and achieved remarkable results (Song & Pan, 2015; Zhou et al., 2017). The ECG localization technology uses the characteristic changes of the P waves during the tube placement to locate the tip of the catheter. The cardiac electrical activity signal received in the intracavitary ECG is stronger than on the body's surface. As the tip of the catheter enters the lower superior vena cava, the amplitude of the P waves is gradually increased, reaching the highest amplitude near the sinus node region. When the catheter tip was far away from the above area, the ECG showed that the amplitude of the P waves was the same as or lower than the body's surface. At present, the intracavitary ECG localization technology is rarely used in patients with persistent atrial fibrillation. Due to the disappearance of the P waves and the appearance of F waves with irregular size and shape on the ECG, the characteristic changes of the P waves during the catheterization process cannot be used to identify the position of the catheter tip. Some researchers have found that the F waves of ECGs in atrial fibrillation patients also change, and its ECG principle may be similar to the change law of sinus P waves (Gao et al., 2018). In this study, we observed the morphological changes of ECG F waves during PICC placement in patients with persistent AF and analyzed its accuracy by comparing it with the chest radiograph results, making a preliminary exploration of the application of ECG localization technology in PICC tip localization. It is reported as follows:

2 | DATA AND METHODS

2.1 | Study subjects

We selected 160 persistent atrial fibrillation patients who required PICC catheterization due to treatment and were hospitalized at Shijiazhuang People's Hospital from August 2018 to October 2021. The clinical data and PICC puncture process were recorded, including 42 patients with malignant tumors and 118 patients with other diseases, among which were 47 with respiratory diseases, 22 with cardiovascular diseases, 23 with cerebrovascular diseases, three with diabetes, 19 with digestive diseases, two with urinary diseases, one with iron deficiency, anemia and one with hyperthyroidism. These patients included 90 males and 70 females, aged 54–99 with an average age of 80.65 ± 8.72 years. Patients who met the following criteria were recruited: (1) due to disease and treatment requiring a long-term infusion and a poor peripheral vascular condition, patients who voluntarily accepted the catheterization and signed informed consent; (2) surface ECG and monitoring showed persistent atrial fibrillation; (3) aged over 18 years old; (4) the chest radiograph examination was allowed to be performed; (5) medication for AF was not taken, or the effect was not obvious after taking the medication. The exclusion criteria included: (1) patients with mental illnesses or skin diseases; (2) a pacemaker or an implantable defibrillator was installed; (3) the patient or the family members did not consent; (4)

the patient also had any other type of central venous catheter. The Ethics Committee of the hospital approved this study.

2.2 | Materials

Materials used in this study included 4Fr peripherally inserted central catheters from US MITAKON, disposable PICC puncture packages, a 12 lead-connected ECG machine (model: EDAN SE-301), a portable ultrasound instrument (model: EDAN-Acclarix-AX8) and sterile connection wires with crocodile clips at both ends.

2.3 | Operation methods

The nurses from the intravenous treatment department who have obtained the PICC placement qualification certificate above the municipal level according to the standardized operation procedure of the hospital PICC tube placement carried out the catheterization operation. The specific procedure included: ① checking the cases, observing and recording the patient's surface ECG; ② selecting blood vessels: the puncture vein was selected in the middle region of the upper arm, the right basilic vein was preferred, and the puncture site was determined and marked under ultrasound guidance; ③ the catheter preset length was accurately measured and calculated using in vitro measurements and placing patients in the supine position. The abduction angle of the upper limb was 90 degrees. Then the length was measured between the prepuncture point and the right sternoclavicular joint, and the length was added or decreased based on height, adding 6 cm to the length with a height of 150–160 cm, adding 7 cm with a height of 160–170 cm and adding 8 cm with a height over 170 cm. The predetermined length was recorded (Zhu et al., 2019). ④ The skin was disinfected, and sterile towels were placed. The prepuncture areas of the upper limbs were disinfected with 75% ethanol and 2% chloride gluconate solution with a sterile treatment towel to establish a maximum sterile barrier. ⑤ Vein puncture and guidewire delivery: an ultrasound-guided combined modified Seldinger technique was used to puncture the vein. After a successful puncture, the guidewire was sent to replace the microtubular sheath. When the catheter was delivered to the predetermined length, ultrasound was used to detect whether the catheter was ectopic to the internal jugular or other veins. If the ECG was connected, one end of the sterile clip connection wire was clipped into the PICC catheter and the other end to the red electrode of the right upper limb. Then 20 ml saline was aspirated into a junction catheter, and the guidewire exported ECG signals by saline and blood to give a continuously stable ECG profile. The F wave amplitude and morphology were observed. If the F wave amplitude increased, the catheter was withdrawn to the F wave amplitude of the height of precatheter placement, and then it was fed until the F wave amplitude increased significantly. The guidewire was removed, flushed with saline, the joints were connected, the pipe was sealed and the

catheter was secured with a sterile dressing. The catheter placement process was recorded, each patient underwent a chest X-ray and the catheter tip position was observed and recorded according to the X-ray results.

2.4 | Data collection for each patient with PICC placement

(1) Patient data included age, gender, and diagnosis. (2) PICC-related data included PICC insertion arm side, puncture vein, and possible puncture-related complications. (3) ECG data included F wave morphology of the surface ECG, F wave morphology at the inferior 1/3 of the superior vena cava, and possible intraoperative complications related to ECG. ECG F waves were jointly identified by cardiovascular and cardiac surgery experts and investigators. (4) Chest X-ray showed the PICC tip position, completed by the imaging doctor and the PICC nurse. When the two were inconsistent, they were judged by the superior doctor in the imaging department.

2.5 | Standard for determining the positioning of the catheter tip

The Infusion Nurses Society (INS) recommends that the PICC tip should be located between the lower 1/3 of the superior vena cava and the cavoatrial junction (Infusion Nurses Society 2016), and some European studies and guidelines suggest that the upper right atrium is also possible (Pittiruti et al., 2009). Studies at home and abroad have shown that the cavoatrial junction (CAJ) corresponded to the 6th–8th thoracic spine level, between the 3rd–4th anterior ribs and the two thoracic vertebrae under the tracheal bulge on the chest X-ray (Wang et al., 2018). This study was based on chest X-ray results. A professional medical imaging physician determined the location of the catheter. The 6th–8th posterior ribs are correctly positioned for the tip of the catheter. Above the sixth posterior rib, the tip position is too shallow. Below the eighth posterior costal gap, the tip position is too deep.

2.6 | Statistical methods

Data statistics were performed by using the SPSS 21.0 statistical software. Counting data were expressed as frequency and percentage, and statistical methods adopted a chi-square test. Measurement data used mean plus or minus standard deviation. The sensitivity (in patients with F wave changes, the tip of the catheter was determined between the lower 1/3 of the superior vena cava and the cavoatrial junction; that is the true positive rate) and specificity (in patients with no change in F waves, the tip of the catheter was not between the lower 1/3 of the superior vena cava and the cavoatrial junction; that is the true negative rate) of determining the PICC

TABLE 1 General data of the patients (n%)

Index	General data (n = 160)	Percentage (%)
Gender		
Male	90	56.25
Female	70	43.75
Malignant tumors	42	26.25
Other disease	118	73.75
Average age	80.7 ± 8.72	
Puncture limb		
Right upper arm	104	65.00
Left upper arm	56	35.00
Puncture vein		
Basilic vein	116	72.50
Brachial vein	43	26.88
Cephalic vein	1	0.62
Catheter length		
	Length measurement	38.01 ± 3.30
	Actual length	38.26 ± 3.22
Puncture site	Length above elbow	10.96 ± 1.73

tip-end position according to the F wave morphological changes of the ECG were calculated by using the screening test method.

3 | RESULTS

3.1 | General data of the patients

A total of 160 clinically eligible cases were selected, including 42 patients with malignant tumors and 118 with other diseases, among which were 47 with respiratory diseases, 22 with cardiovascular diseases, 23 with cerebrovascular diseases, three with diabetes, 19 with digestive diseases, two with urinary diseases, one with iron deficiency anemia and one with hyperthyroidism. These patients included 90 males and 70 females with an average age of 80.7 ± 8.72 years (Table 1).

3.2 | Comparison of ECG localization results and chest X-rays in patients with atrial fibrillation

The results of the comparison of intracavity ECG localization and chest slice positioning in 160 patients with persistent atrial fibrillation showed 143 cases with an F wave amplitude of more than 0.2 mv, 117 presented with appropriate tip position of the catheter in the chest X-ray, 24 were too deep, two were too shallow, and of the 17 cases with an F wave amplitude less than 0.2 mv, five had a tip position of the catheter that was too deep on the chest X-ray, five were too shallow, and seven had an ectopic catheter tip (ipsilateral subclavian vein reflection in one case, contralateral subclavian vein in one case, azygos vein in two cases, ipsilateral brachiocephalic vein reflection in one case, and contralateral brachiocephalic vein in two cases). Sensitivity was 93.46% and specificity was 100% (Table 2).

3.3 | ECG F wave changes in patients with persistent atrial fibrillation

The ECG P waves of patients with persistent AF disappeared and were replaced by F waves with irregular size and shape (Figure 1). Therefore, the tip position of the catheter cannot be judged by P wave changes on the conventional ECG. In the process of PICC placement, the F wave changes were similar to the P waves. Figures 1 and 2 show the intracavity ECG changes of F waves more than 0.2 mv and less than 0.2 mv, respectively.

3.4 | Distribution of different F wave amplitudes in intracavity ECGs in patients with atrial fibrillation

From the distribution of increased F wave amplitude in 160 AF patients compared with chest X-ray results, the proportion of appropriate positioning and over depth of the catheter tip was above 31.25% for F

wave amplitudes over 0.3 mv, and the F wave amplitude was below 0.1 mv for the ectopic catheter and over the shallow position (Table 3).

4 | DISCUSSION

4.1 | Exploration of intracavity ECG localization in patients with atrial fibrillation

In recent years, domestic and foreign studies have demonstrated that the intracavity ECG localization technology can accurately locate the position of the PICC tip, and the principle is to locate it through the specific changes of the P wave during the catheter placement process. The P wave is unchanged when the catheter tip is located in the peripheral veins or ectopic to the internal jugular vein, the contralateral subclavian vein, reflection in the ipsilateral subclavian vein, or the axillary vein. When the tip of the catheter enters the central superior vena cava, the P wave amplitude gradually

TABLE 2 Comparison of ECG characteristic f-wave localization and chest X-ray localization in patients with atrial fibrillation (n%)

Chest X-ray localization	Number (n)	Percentage (%)	Intracavity ECG characteristic P waves		Sensitivity (%)	specificity (%)
			f \geq 0.2 mv	f<0.2 mv		
Appropriate tip position (T6-T8)	117	73.12	117	0	93%	100%
Deep tip position (\geq T9)	29	18.12	24	5		
Shallow tip position (\leq T5)	7	4.38	2	5		
In total n	153		143	10		
Ectopic position (not superior vena cava)	7	4.38	0	7		
In total (n)	160	100%	143	17		

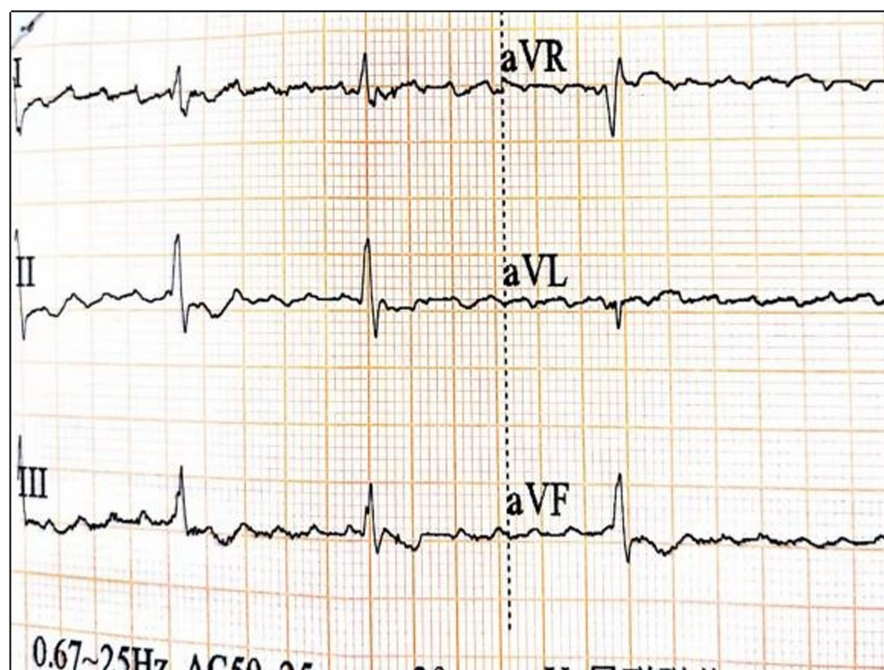


FIGURE 1 Intracavity ECG of f wave less than 0.2 mv

FIGURE 2 Intracavity ECG of f wave more than 0.2 mv

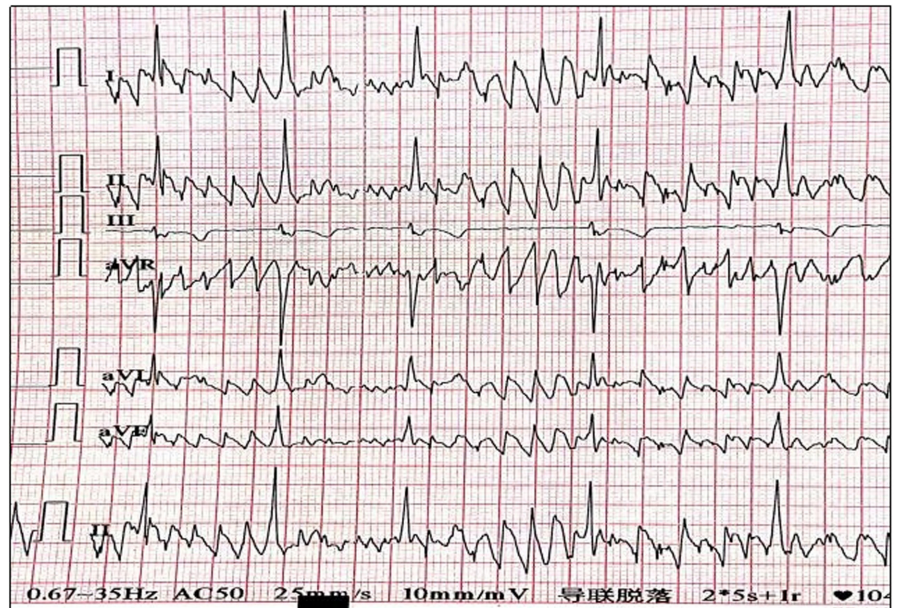


TABLE 3 Distribution of different amplitude of intracavity ECG f waves in patients with atrial fibrillation (n%)

F wave		Example location of X-ray chest slices				
f wave amplitude (mv)	Number (n)	Appropriate position (T6-T8)	Overshallow ($\leq T5$)	Overdepth (≥ 9)	Ectopic position(not superior vena cava)	Percentage (%)
0	2	0	0	0	2	1.25
0.05	5	0	2	0	3	3.13
0.1	10	0	3	5	2	6.25
0.2	27	21	2	4	0	16.88
0.3	50	41	0	9	0	31.25
0.4	31	29	0	2	0	19.38
0.5	16	13	0	3	0	10.00
0.6	7	5	0	2	0	4.38
0.7	5	4	0	1	0	3.13
0.8	1	0	0	1	0	0.63
0.9	1	1	0	0	0	0.63
1	1	1	0	0	0	0.63
1.1	1	0	0	1	0	0.63
1.2	1	1	0	0	0	0.63
1.3	1	1	0	0	0	0.63
1.4	0	0	0	0	0	0.00
1.5	1	0	0	1	0	0.63
In total (n %)	160	117	7	29	7	100.00

increases in a positive waveform with a unimodal or double peak (Sun et al., 2017; Zhang et al., 2019). There are few studies on ECG localization technology in arrhythmia patients. Domestic researchers used intracavity ECG localization technology in patients with lung cancer after cardioversion, suggesting that it is safe and feasible to administer PICC under ECG guidance in patients with atrial flutter (Liu, 2011). For patients with persistent AF, P waves on ECG disappeared and were replaced with irregularly shaped F waves. It has been reported abroad that the amplitude of PICC was increased

with the depth of the catheter tip during the placement of PICC in patients with persistent atrial fibrillation. When the PICC tip reaches the lower 1/3 of the superior vena cava, the F wave amplitude is highest, similar to the P wave changes in patients with normal surface ECGs (Gao et al., 2018). In this study, ECG localization technology was used in patients with AF. We found that when the catheter was sent into a predetermined length, the F wave amplitude on the limb lead was significantly higher than before the PICC placement. The F wave fell back as the catheter withdrew, indicating that the F

wave of AF patients can also be used as a basis for determining the tip location of the catheter. Due to the different sizes and directions of ECG F waves, fast and irregular waves, and no isopotential line between F waves in AF patients, it is difficult to judge the baseline. Although the catheter tip location cannot be judged by recording the specific values of the positive and negative P wave amplitude, as in patients with sinus rhythm, the F wave amplitude had clinical significance for determining the catheter tip position. We measured the F wave amplitude on the limb lead II, and the highest F wave peak indicated that the catheter tip had reached the proper location.

4.2 | Safety and accuracy of ECG localization in patients with AF

At present, for patients with atrial fibrillation, the tip position is primarily clinically determined by pre-PICC measurements and post-PICC chest X-rays. This study showed that the average age of patients with persistent AF was 80.65 ± 8.72 years. Most of them had a variety of diseases, and some were unable to get out of bed; thus, chest X-rays are an inconvenience to them. Due to the shooting position and equipment type, the pictures are not clear. It is difficult to judge the results in time and easy to cause radiation damage to patients and medical staff in the same ward. Such patients are in urgent need of easy, timely, and safe clinical positioning methods. In this study, 160 patients with persistent atrial fibrillation underwent intracavity ECG PICC tip localization with no complications associated with it, such as palpitations, aggravated chest tightness, and dyspnea after catheter placement, initially demonstrating the safety of the technique for PICC tip positioning in patients with AF. There was no significant difference between ECG and chest X-ray localizations. The accuracy of the intracavity ECG localization was evaluated by screening tests using chest X-ray results as the gold standard. Sensitivity was 93.46%; that is, in patients with F wave changes, the correct rate of the catheter tip reaching the superior vena cava by chest X-ray was 93.46%. The specificity was 100%; that is, the correct rate of the catheter tip not reaching the superior vena cava by intracavity ECG and chest X-ray was 100%. Minor changes in F waves in seven ectopic patients were consistent with the surface ECG. Of the seven cases, one had the tip in an ectopic reflection in the ipsilateral subclavian vein, one was in the contralateral subclavian vein, two were in the azygos vein, one had ipsilateral brachiocephalic vein reflection and two were in the contralateral brachiocephalic vein. We tracked down 160 cases through a retrospective study. Patients with atrial fibrillation generally do not exceed 0.1 mv due to the low F wave amplitude. This study used the F wave amplitude increased by 0.2 mv. There were 143 patients with F waves exceeding 0.2 mv on intracavity ECG and 117 patients with appropriate catheter tip position, accounting for 81.82% (117/143), indicating its clinical significance. The catheters of 24 patients were too deep, two were too shallow, but all were in the superior vena cava with no ectopic cases. When the catheter position is too deep, the ECG is as high as 1.1 mv, which can be corrected by withdrawing

the catheter. A position that is too shallow may be related to cutting the catheter and measurement error before placement. Before the delivery, the catheter has been cut and cannot be compensated. We can reserve the catheter length as much as possible before cutting. A total of 17 cases had intracavity ECG F waves less than 0.2 mv, including seven with an ectopic catheter, five with a catheter tip that was too shallow and five with a catheter tip that was too deep, with a greater chance of slight F wave increase. The odds of the ectopic catheter are higher with a slight F wave increase.

4.3 | Limitations of ECG technology used for PICC tip positioning

This study showed that the intracavity ECG technique guiding PICC catheterization in patients with AF to effectively monitor the catheter tip into the inferior superior vena cava and prevent ectopic catheter to the internal jugular vein and contralateral inferior subclavian vein. Due to the different sizes and directions of ECG F waves, fast and irregular waves and no isopotential lines between F waves in AF patients, it is difficult to judge the baseline. It is impossible to judge whether the catheter is appropriate by specific values of the positive and negative P wave amplitudes and the change in the F wave amplitudes of the catheter into the right atrium and inferior vena cava, as in patients with sinus rhythm. This study preliminarily explored the relationship between the F wave amplitude height and the position of the catheter tip. However, due to the limited samples, the detailed F wave morphological changes and amplitude measurements need further investigation. The accuracy and reliability of intracavity ECG techniques for PICC tip localization in patients with persistent atrial fibrillation need to be explored and validated by further expanding the sample size. The amplitude increase was not apparent for the F wave, but the chest slice shows the catheter was too deep. The possible reason is that the surface ECG F wave amplitude was too low. The other reason may be when the catheter is too deep. Sinus rhythm patients on the intracavity ECG also showed a smaller P wave amplitude fall, but amplitude increased with catheter withdrawal, and F wave amplitude fall is estimated to be the same as the intracavity ECG of sinus rhythm. For catheters that were too deep or shallow in the cases with F waves less than 0.2 mv, the specific reasons are unclear, which suggests that the method of ECG localization can be optimized in the next step to improve the elicit rate of specific F waves and increase the accuracy of ECG localization.

5 | CONCLUSION

The ECG localization technology has specific clinical guidance for PICC tip positioning in patients with AF, and its safety and accuracy are fair. For paroxysmal atrial fibrillation patients requiring PICC catheterization, ECG-specific P wave changes can be used to locate the tip position of the catheter if the ECG is in sinus rhythm before catheter placement. In patients with persistent AF, the increase in

ECG F wave amplitudes during catheterization responds to some extent whether the catheter tip entered the inferior vena cava, and there were no complications associated with ECG localization during or after catheter placement. Due to the characteristics of the ECG F wave of patients with atrial fibrillation, we cannot measure the accurate value of the F wave amplitude. It is difficult to determine the depth of the catheter by whether the F wave is negative, but the significant increase in the amplitude of the F wave compared with before catheter placement can also be used as the basis for judging the position of the catheter tip. Although the height and distribution of the F wave amplitude have been explored in this study, the accurate determination of catheter positioning using the specific values of F wave amplitudes in persistent AF patients needs to be further explored and verified by expanding the sample size.

ACKNOWLEDGMENTS

Not applicable.

CONFLICTS OF INTERESTS

All of the authors had no any personal, financial, commercial, or academic conflicts of interest separately.

AUTHOR CONTRIBUTIONS

Conghui Zhao and Yuxin Zhu conceived of the study and Xinxin Yin and Congcong Zhang participated in its design and coordination and Yingxia He and Jingfang Gao helped to draft the manuscript. All authors read and approved the final manuscript.

ETHICAL APPROVAL

This study was conducted in accordance with the Declaration of Helsinki and approved by the ethics committee of Shijiazhuang People's Hospital.

CONSENT FOR PUBLICATION

Not applicable.

DATA AVAILABILITY STATEMENT

All data generated or analyzed during this study are included in this published article.

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REFERENCES

- Gao, Y., Liu, Y., Zhang, H., Fang, F., & Song, L. (2018). The safety and accuracy of ECG-guided PICC tip position verification applied in patients with atrial fibrillation[J]. *J Therapeutics and Clinical Risk Management*, 14, 1075–1081.
- Journal of Infusion Nursing. (2016). Infusion nursing standards of practice. *Journal of Infusion Nursing*, 39(15):S46.
- Liu, H. M. (2011). In atrial ECG guiding PICC localization after atrial flutter 1 case[J]. *Journal of Nanchang University*, 51(11), 104–105.
- Nan, J., & Yang, S. X. (2015). Progress in paroxysmal atrial fibrillation and stroke[J]. *Chinese Journal of Geriatric Heart Brain and Vessel Diseases*, 17(6), 665–668.
- Pittiruti, M., Hamilton, H., Biffi, R. MacFie, J & Pertkiewicz, M. (2009). ESPEN guidelines on parenteral nutrition: Central venous catheters (access, care, diagnosis and therapy of complications). *Clinical Nutrition*, 28(4), 365–377. <https://doi.org/10.1016/j.clnu.2009.03.015>
- Song, B. H., & Pan, G. F. (2015). Application of ECG characteristic P-wave in PICC tip alignment[J]. *Modern Nursing*, 21(14), 1675–1677.
- Sun, H., Wang, L., & Nie, S. X. (2017). The ECG method for positioning the tip of peripherally inserted central catheter: Results of a multi-center study[J]. *Chinese Journal of Nursing*, 52(8), 916–920.
- Wang, J., Lin, M., Wei, L. et al (2018). A clinical controlled trial of two different PICC catheter positioning methods[J]. *Modern Nursing*, 24(3), 336–339.
- Zhang, X. X., Li, L. K., Duan, S. M. et al (2019). Directive function of intracavitary electrocardiogram bimodal P-wave in the position of PICC tip[J]. *Chinese Journal of Practical Nursing*, 35(6), 412–415.
- Zhou, L., Xu, H., Liang, J., Xu, M., & Yu, J (2017). Effectiveness of intracavitary electrocardiogram guidance in peripherally inserted central catheter tip placement in neonates[J]. *The Journal of Perinatal & Neonatal Nursing*, 31(4):326-333.
- Zhu, Y. X., Zhang, X., Liu, C. X. et al (2019). Effects of measurement method of body surface according to the body height of patients plus different numbers on PICC ideal arrival location rate[J]. *Hebei Medical Journal*, 41(11), 1749–1752.

How to cite this article: Zhao, C., Zhu, Y., Yin, X., Zhang, C., He, Y., & Gao, J. (2022). ECG method for positioning the tip of peripherally inserted central catheters in patients with atrial fibrillation. *Annals of Noninvasive Electrocardiology*, 27, e12931. <https://doi.org/10.1111/anec.12931>