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## **Ultrasound guidance for femoral venous access in patients undergoing pulmonary vein isolation: a quasi-randomized study**

Vascular ultrasound-guided puncture is beneficial

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## **Abstract**

### **Introduction**

Routine ultrasound (US)-guidance for femoral venous access to decrease vascular complications of atrial fibrillation (AF) ablation procedures has been advocated. However, the benefit has not been unequivocally demonstrated by randomized-trial data.

### **Methods and Results**

Consecutive patients undergoing pulmonary vein isolation (PVI) on uninterrupted anticoagulant treatment were included. A quasi-random allocation to either US-guided or conventional puncture group was based on which of the two procedure rooms the patient was scheduled in, with only one of the rooms equipped with an US machine including a vascular transducer. The same 4 novice operators in rotation, with no relevant previous experience in US-guided vascular access performed venous punctures in both rooms. Major and minor vascular complications and the rate of prolonged hospitalization were compared. Major vascular complication was defined as groin hematoma, arteriovenous fistula, or pseudoaneurysm. Hematoma was considered as a major vascular complication if it met type 2 or higher Bleeding Academic Research Consortium criteria (requiring nonsurgical, medical intervention by a health care professional; leading to hospitalization or increased level of care, or prompting evacuation). Of the 457 patients 199 were allocated to the US-guided puncture group, while the conventional, palpation-based approach was performed in 258 cases. Compared to the conventional technique, US-guidance reduced the rate of any vascular complication (11.63% vs. 2.01%,  $p<0.0001$ ), including both major (4.26% vs. 1.01%,  $p=0.038$ ) and minor (7.36% vs 1.01%,  $p=0.001$ ) vascular

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complications. In addition, the rate of prolonged hospitalization was lower in the US-guided puncture group (5.04% vs. 1.01%,  $p=0.032$ ).

### **Conclusion**

The use of US for femoral vein puncture in patients undergoing PVI decreased the rate of both major and minor vascular complications. This quasi-randomized comparison strongly supports adapting routine use of US for AF ablation procedures.

**Keywords:** ultrasound-guided puncture, electrophysiology procedures, vascular access, pulmonary vein isolation, complications

### **Introduction**

Catheter ablation for atrial fibrillation (AF) is by far the most often performed cardiac ablation procedure worldwide. (1–4) Although the complication rate of AF ablation procedures is low, they may prolong hospitalization and often interfere with the QoL of the patients. (5,6) The most frequent complications of these procedures are related to vascular access ranging in frequency from 1 to 13%. (5,7,8)

Traditionally, femoral vein puncture is guided by palpation of the femoral artery below the inguinal ligament and the needle is inserted next to the pulsation to target the femoral vein. However, the position of the femoral vessels in relation to each other is variable. (9) Vascular ultrasound (US)-guidance can clarify the anatomy of the femoral vessels, identify variations that may interfere with the puncture and thereby decrease access-related complications (Figure 1.).

Routine use of US to guide femoral access during electrophysiology (EP) procedures has been advocated, however its universal adoption has been hampered by the lack of randomized-trial data unequivocally showing its benefit. Prior meta-analyses demonstrated that US guidance for femoral vein punctures in EP procedures reduces the rate of both major and minor vascular complications. (10,11) To date, only 1

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randomized, controlled trial (RCT) investigated the potential benefits associated with the use of US for femoral venous access in patients undergoing AF ablation procedures. (12) Although US guidance improved intraprocedural outcomes, there was no difference in the major complication rates presumably due to the lower-than-expected complication rate in the conventional arm.

We aimed to provide a quasi-randomized comparison of the two techniques taking advantage of the fact that early in our experience with the use of US-guided access only one of our two procedure rooms was equipped with a vascular US-probe.

## **Materials & methods**

### Patient population

Consecutive patients older than 18 years undergoing pulmonary vein isolation (PVI) for AF with standard indications on uninterrupted anticoagulant treatment were prospectively included. Patients on novel oral anticoagulants did not skip any dose even in the morning of the procedure. The target international normalized ratio (INR) for those who were taking vitamin K antagonist (VKA) was 2.0 - 3.0. We excluded patients referred for a redo procedure.

### Femoral venous access

Patients were grouped based on whether US guidance was used for femoral venous access. Allocation to each of the two groups was quasi-randomized according to which of the two procedure rooms the patient was scheduled in, without preference. Only 1 of the rooms had vascular US capability and all venous punctures during PVI procedures in this room were performed US-guided. The conventional, palpation-based method was applied in the other room in all cases. Both procedure rooms were equally equipped except for the ultrasound machine. The same 4 novice operators in

rotation, with no relevant previous experience in US-guided vascular access performed venous punctures in both rooms.

For vascular US an 8 MHz linear transducer connected to a portable echocardiograph (Vivid I, GE Health Medical, Horten, Norway) was used. The transducer was covered with a sterile sleeve and placed at a 90-degree angle to the course of the vein at the groin to obtain a transverse view for vascular US-guided femoral vein puncture.

#### Ablation procedure

After local anaesthesia, an 18-gauge needle was used for femoral vein puncture and guidewire insertion. Two punctures were performed on both left and right femoral veins. An 11-French (Fr) and a 6-Fr sheath was inserted in the left, while an 8 and an 8.5-Fr long sheath was placed in the right femoral vein. PVI was performed using point-by-point radiofrequency ablation supported by CARTO electroanatomical mapping system (Biosense Webster Inc., Diamond Bar, CA, USA). Intracardiac echocardiography (ICE) was applied to guide the procedure including transseptal puncture. Heparin was administered intravenously just before transseptal puncture, when tenting of the fossa ovalis was visualized by ICE. Activated clotting time (ACT) was targeted between 300-350 s during the procedure. The endpoint for the procedures was pulmonary vein isolation after 20 minutes waiting period. When the procedural endpoint was achieved, catheters were removed and transseptal sheaths were pulled back to the right side of the heart. Reversal of heparinization with intravenous protamine was applied followed by sheath removal at ACT < 200 s and manual compression until hemostasis was achieved. A compressive bandage was applied over both groins and was left in place for 6 hours. Patients were discharged at the first postoperative day. The occurrence of vascular complications was systematically evaluated during the hospitalization.

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## Study endpoints

The primary endpoint was the composite rate of major and minor vascular complications. The frequency of prolonged hospitalization was also compared between the two groups. Major vascular complications included groin hematoma, arteriovenous fistula, or pseudoaneurysm. Hematoma was considered as a major vascular complication if it met type 2 or higher Bleeding Academic Research Consortium (BARC) criteria (requiring nonsurgical, medical intervention by a health care professional; leading to hospitalization or increased level of care, or prompting evacuation). The Type 1 BARC criteria define bleeding as non-actionable and not causing the patient to seek unscheduled medical attention, and hematomas that met these criteria were considered minor vascular complications. (13) The definition of prolonged hospitalization in this study referred to a patient's stay in the hospital more than one night following the completion of the ablation procedure.

The protocol of the study is in accordance with the Declaration of Helsinki and the study protocol was approved by the regional ethics committee. All patients provided written informed consent.

## Statistical analysis

Parametric data are presented as mean and standard deviation. Categorical data are presented as percentage. Data were analyzed according to their normal distribution on the Shapiro goodness-of-fit test. Categorical variables were compared using chi-square test. A p value <0.05 was considered statistically significant in all analyses. Statistical analyses were performed using SPSS 24 software (SPSS, Inc., Chicago, IL, USA).

## Results

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Of 457 patients 199 were allocated to ultrasound guided puncture group, while the conventional, palpation-based approach was performed in 258 cases. There was no difference in patients' baseline characteristics between the groups (Table 1). Compared to the conventional technique, US-guidance reduced the composite rate of minor and major vascular complications (11.63% vs. 2.01%,  $p < 0.0001$ ). The use of US significantly reduced both major (4.26% vs. 1.01%,  $p = 0.038$ ) and minor (7.36% vs. 1.01%,  $p = 0.001$ ) vascular complications. The absolute risk reduction (ARR) of minor/major vascular complications was 9.62% equated to a relative risk reduction (RRR) of 82.71%, and a number needed to treat (NNT) of 10 to prevent one bleeding event. The decrease in the rate of prolonged hospitalization was also statistically significant (5.04% vs. 1.01%,  $p = 0.032$ ). Results are shown in Figure 2. and Table 2.

## Discussion

In this prospective, quasi-randomized comparison US-guided femoral vein puncture improved the safety of AF ablation procedures compared to the conventional, palpation-based technique. US guidance was associated with lower composite, major and minor vascular complication rates.

The most common complications of the EP procedures are related to the vascular access. (5,6) AF ablations carry the highest risk for these types of events, which can be explained by the use of large and multiple sheaths and uninterrupted, periprocedural anticoagulant treatment. (7,14,15)

Vascular US-guidance during femoral access provides real-time visualization of the inguinal vessels and the surrounding structures, identifying anatomical variations. (16) Additionally, it allows following of the needle during the puncture to guide and correct its course. (17)

Several non-randomized, observational studies showed the superiority of the US-guided technique in the rate of vascular complications of AF ablation (18–20), however the only one RCT failed to meet its primary endpoint. (12)

A retrospective trial involving 3,420 patients undergoing PVI for AF showed, that US-guided femoral vein puncture improves the safety profile of PVI procedures by reducing total, major and minor vascular complications. (18) Although the rate of these complications was low even in the non-US group (1.7%), the benefit from US guidance was clearly demonstrated by a 70.6% relative risk reduction.

In the multicentre ULTRA-FAST RCT 320 patients, who underwent an AF ablation procedure were randomized to US-guided or conventional vein puncture. The study was prematurely terminated before meeting its primary endpoint of reduction in vascular complications due to substantially lower-than-expected complication rates, which doubled the population size needed to maintain statistical power. (12) Only 4 major vascular complications occurred during the whole study period (1 (0.6%) in the US and 3 (1.9%) in the conventional arm). Nonetheless, beneficial intraprocedural outcomes - including shorter puncture time, fewer inadvertent arterial puncture and higher first pass success rate - were associated with US-guidance.

In a prior meta-analysis by Sobolev et. al US-guided femoral vein puncture reduced the rate of major vascular complications in patients undergoing EP procedures. (10) Furthermore, another larger meta-analysis confirmed these findings and demonstrated 73% risk reduction in major vascular complications with US-guidance in PVI procedures. (11) Interestingly, in one retrospective single-centre trial including 4,734 patients undergoing AF ablation procedures the benefit of US guided femoral vein puncture was found in males only. (21) A most recently published retrospective analysis involving more than 10,000 and including 4,356 AF patients also

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demonstrated, that major vascular complications are exceedingly rare with use of US for vascular access. (22) Vascular US for vessel puncture in EP procedures proved to be a cheap, easy-to-learn tool (23), and is cost effective. (24)

In spite of the observational results the use of US to guide vascular access has still not been adopted by many EP centres worldwide. (22) While the lack of convincing RCT data supporting US use discourages these to change their practice, others are reluctant to omit US in any patient even for the sake of performing such an RCT. (25) Our quasi-randomized analysis may serve as a substitute for a true RCT. We prospectively collected data on patients who underwent PVI during the same period, by the same operators, but were randomly assigned to US-guidance based on its availability. The results demonstrate a remarkable improvement in the risk of vascular complications and serve as a basis for a more widespread adaptation of the technique of US-guided femoral access for AF ablation.

### **Limitations**

Our series is a single center study, which could limit its generalizability to other centers. Although the study was randomized, it could not be blinded. The femoral vein punctures were performed by EP fellows in training with no relevant experience in US-guided vascular access. We did not collect data about puncture time and subclinical vascular complications as inadvertent femoral artery puncture. In addition, it cannot be ruled out that some of the complications occurred due to inadequate manual compression after sheath removal.

### **Conclusion**

Using US for femoral vein puncture in patients undergoing PVI decreased the rate of both major and minor vascular complications. This quasi-randomized comparison strongly supports adapting routine use of US for AF ablation procedures.

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**Table 1. Clinical characteristics of the study population.**

Abbreviations: DOAC - direct oral anticoagulant; EF - ejection fraction; INR - international normalized ratio; n.s. - non significant; US - ultrasound; VKA - vitamin K antagonist

	<b>Conventional puncture group (n=258)</b>	<b>US-guided puncture group (n=199)</b>	<b>p-value</b>
<b>Sex, male (%)</b>	145 (56.2)	113 (56.8)	n.s.
<b>Age, years</b>	63.5 ± 9.4	62.8 ± 10.7	n.s.
<b>Hypertension (%)</b>	190 (73.6)	158 (79.4)	n.s.
<b>Diabetes mellitus (%)</b>	46 (17.8)	39 (19.6)	n.s.
<b>Heart failure with reduced EF (%)</b>	18 (7.0)	14 (7.0)	n.s.
<b>Body mass index</b>	29.7 ± 4.7	28.5 ± 4.1	n.s.
<b>DOAC use (%)</b>	145 (56.2)	127 (68.8)	n.s.
<b>INR in patients on VKA treatment</b>	2.1 ± 0.5	2.2 ± 0.5	n.s.

**Table 2. Comparison of major complications, minor complications and prolonged hospitalization between conventional vs. ultrasound guided femoral vein puncture group.**

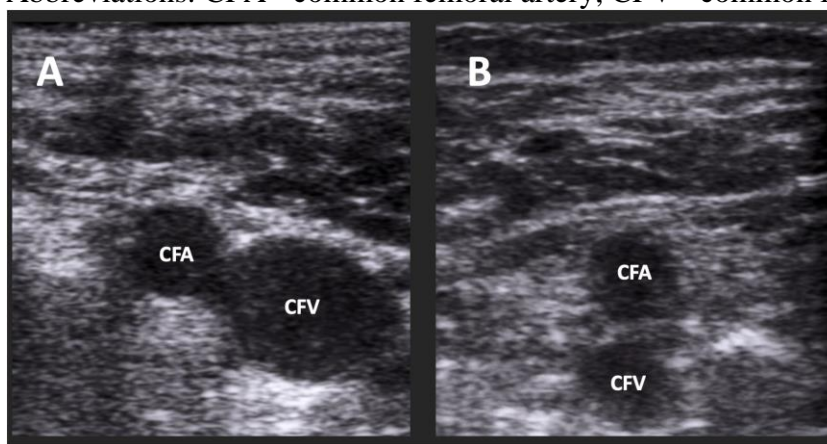
Abbreviation: US - ultrasound. See Methods section for definitions.

	<b>Conventional puncture group (n=258)</b>	<b>US-guided puncture group (n=199)</b>	<b>p-value</b>

<b>Total vascular complications (%)</b>	30 (11.63)	4 (2.01)	<0.001
<b>Minor vascular complications (%)</b>	19 (7.39)	2 (1.01)	0.001
<b>Major vascular complications (%)</b>	11 (4.26)	2 (1.01)	0.038
<b>Prolonged hospitalization (%)</b>	13 (5.04)	2 (1.01)	0.032

**Figure 1. Illustrative examples of two-dimensional vascular ultrasound images of the femoral vessels with usual (Panel A) and unusual (Panel B) localization.**

Abbreviations: CFA - common femoral artery, CFV - common femoral vein



**Figure 2. Comparison of major complications, minor complications and prolonged hospitalization between conventional vs. ultrasound guided femoral vein puncture group.** Abbreviation: US - ultrasound

