Received: 17 April 2024 | Revised: 21 June 2024 | Accepted: 26 June 2024

DOI: 10.1002/joa3.13111

Journal of Arrhythmia Open Access WILEY

ORIGINAL ARTICLE

Using point-of-care ultrasound to determine incidence of deep vein thrombosis after right-sided radiofrequency catheter ablation

Reema Qayoom MBBS, FCPS Cardiology | **Hannah S. Asghar MD** | **Irfan Amjad Lutfi MBBS, MD, Fellowship in VIR (Singapore) & Neuro Interventional (USA)** | **Faisal Qadir MBBS, FCPS Medicine, FCPS Cardiology** | **Ghazala Irfan MBBS, FCPS Cardiology** | **Azam Shafquat MD**

National Institute of CardioVascular Diseases, Karachi, Pakistan

Correspondence
Reema Qayoom, National Institute of CardioVascular Diseases, A-1238 Gulshan-e-Hadeed, Phase 1(1st Floor), Bin Qasim, Karachi, Pakistan.
Email: dr.reemaqayoom@gmail.com

Abstract

Introduction: Femoral venous access is routinely used for radiofrequency catheter ablation (RFA) procedures. Deep vein thrombosis (DVT), which is often sub-clinical, is uncommon following RFCA. Point-of-care ultrasound (POCUS) is a cost-effective way to diagnose DVT. Identification of DVT incidence, especially if sub-clinical, can direct change in practice to reduce DVT and lay ground for cost-effective screening strategies postprocedures. The aim of our study is to determine the incidence of DVT after right-sided radiofrequency cardiac catheter ablation using POCUS.

Methods: We conducted a single-center prospective cross-sectional study in patients undergoing right-sided RFCA. Within 24 h postprocedure, the participants underwent compression venous duplex ultrasonography using POCUS to look for evidence of DVT in cannulated limb. The contralateral limb that was not cannulated was scanned as a control.

Results: A total of 194 patients were scanned post-right-sided RFCA procedures. Average age was 43.5 ± 13.2 years and 131 (67.5%) were women. A total of 148 (76.3%) patients underwent AVNRT ablation. Ten (5.2%) patients developed DVT, of which nine had sub-clinical DVT. Age (>53 years), greater sum of sheaths used (>3) and longer duration of bed rest maintained (up to 4.0 h vs. >4.0 h, $p = 0.006$) were identified as risk factors.

Conclusion: Most of the DVTs after right-sided catheter ablation are sub-clinical. Routine scanning for DVT after right-sided catheter ablation as well as reducing number of sheaths and bed rest should be considered.

KEYWORDS
complications of cardiac arrhythmias, deep venous thrombosis (DVT), electrophysiology study and radiofrequency catheter ablation, point-of-care ultrasonography (POCUS)

1 | INTRODUCTION

Supraventricular tachycardias (SVTs) are routinely treated by performing electrophysiology[1–5] (EP) study and radiofrequency catheter ablation (RFCA) with a high cure rate and improved quality of life.[6,7] The mainstay of EP procedure is femoral venous access for catheter insertion.[8] Left-sided RFCA has lower risk of DVT as a result of periprocedural administration of anticoagulation[9] but it may be problem in right-sided procedures. A single prospective multi-center study showed 10% incidence of DVT following right-sided catheter ablation, among 71 participants using conventional departmental ultrasound.[4] Ninety-day mortality rate with sub-clinical proximal DVT was found to be 13.75%[10] in literature. A multi-item survey of 244 cardiac electrophysiologists, reported that at least 13% of participants observed one DVT and 9% observed at least one pulmonary embolism (PE) after right-sided RFA in last year at their center.[6] Moreover, widely variable clinical practices for DVT prevention were noted with two-thirds (67%) of electrophysiologists never using DVT prophylaxis while 17% routinely prescribed low-molecular-weight heparin (LMWH) and 14% routinely prescribed aspirin following right-sided RFA.[6]

Duplex ultrasound performed by a radiology department is standard of care to diagnose DVT but routine ultrasound postprocedure in all patients is resource and logistically challenging. Point-of-care ultrasonography (POCUS) is widely available and less resource intensive and can diagnose DVT by assessing compressibility of deep veins or direct visualization of thrombus. POCUS results are comparable with conventional ultrasound.[6] Identification of all factors that can increase risk for DVT which is potentially life-threatening so they can be mitigated is crucial as most right-sided ablations are performed to cure bothersome palpitations rather than to decrease mortality.

2 | METHODOLOGY

A single-center prospective cross-sectional study was conducted from December 2022 to December 2023 after getting approval from the Institutional Ethical Review Committee (ERC = 056/2022). Age is stratified into four quartiles and 75th quartile (≥53 years) is used as cut-off. Patients who received prophylactic or therapeutic heparin were excluded. Heparinized flushes were used as standard practice. Choice of venous access and number of sheaths were as per operator's discretion. Postprocedure manual compression was maintained for 5 min after sheath removal in all patients as per routine. Further compression was maintained if bleeding was noted with coughing. Compression dressing using gauze at site and elastic tape to maintain pressure was applied.

Patients were evaluated within 24 h prior to discharge. Clinical symptoms and signs of DVT including asking for pain at site and examination for warmth, tenderness, and swelling of calf compared to contralateral limb were recorded.

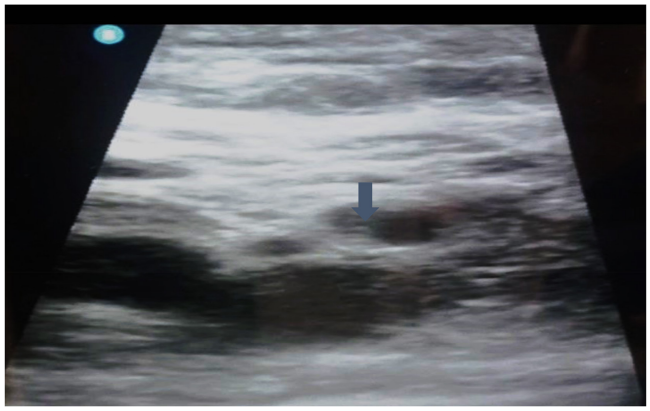

FIGURE 1 Noncompressibility and visualization of layered thrombus in common femoral vein using POCUS.

We performed 2-point venous compression at level of common femoral vein and popliteal vein as described in literature using POCUS,[11] to screen DVT within 24 h postcardiac catheter ablation procedure, before discharge. The noncannulated opposite lower limb was scanned and used as a control to ensure that findings could be linked to instrumentation of the limb used for access. Ultrasound details and POCUS videos showing DVT are provided in supplementary data. POCUS was performed by cardiac electrophysiology fellow who has training in General Cardiology and has certification in special competence Echocardiography from the National Board of Echocardiography, USA. Training criterion included didactic review of online academic videos on performing POCUS and didactic training by cardiologist with certification in ultrasound vascular imaging, followed by 25 cases performed under supervision. Supervising cardiologist who confirmed finding has certification in ultrasound vascular imaging. In case of ambiguity of findings, a confirmatory ultrasound procedure was performed by radiologist.

Patients without signs or symptoms of DVT but ultrasound showing DVT (Figure 1) were classified as sub-clinical DVTs. All patients with diagnosis of DVT were prescribed 3 months of oral anticoagulation as per guidelines.[12] Patients were followed after 3 months of anticoagulation with no major bleeding event. Patients were followed up in clinic at regular intervals (i.e., 1 months, 3 months, and 6 months) after procedure with no signs and symptoms suggestive of pulmonary embolism. However, specific diagnostic tests were not performed to rule out pulmonary embolism in asymptomatic patients.

Inclusion Criteria:

- Age > 18 years who received clinically indicated RFCA for atrioventricular nodal re-entrant tachycardia or atrioventricular re-entrant tachycardia with right-sided accessory pathway

Exclusion Criteria:

- Diagnostic electrophysiology study only (no ablation performed)
- Perioperative therapeutic anticoagulation

- Periprocedural complications that would, in the opinion of the PI/designee, preclude further participation in the study
- Postprocedure bleeding or hematoma formation requiring prolonged (>30 min) pressure
- Intubated/ventilated patients
- Previous cardiac ablation within 6 months
- Documented atrial flutter or atrial fibrillation
- Documented previous venous thrombosis or pulmonary embolism
- Known coagulopathy or anticoagulant use
- Known malignancy
- Cannulation of both groins
- Declined consent

2.1 | Data analysis

Using an incidence of 10% as per literature with 5% error, a sample size of 194 was used. Analysis of collected data was performed with the help of IBM SPSS version 21. The categorical response variables, including the incidence of DVT, were expressed as frequencies and percentages, and mean ± standard deviation (SD) was reported for continuous variables. The association between incidence of DVT and various demographic and clinical factors was assessed by conducting the Chi-square test or Fisher's exact test, appropriately, while independent sample t-test/Mann–Whitney *U*-test was applied for the comparison of mean values between the DVT and non-DVT group. Statistical significance criteria were p-value less than 0.05 for all the analyses.

TABLE 1 Distribution of demographic and clinical characteristics of patients who undergone right-sided catheter ablation.

	Total
Total (*N*)	194
Female	67.5% (131)
Mean age (years)	43.5 ± 13.2
Age > 53 years	31% (62)
Median body mass index (kg/m^2)	26 [22.9–28.2]
Smoking status	
Never smoked	82% (159)
Ex-smoker	4.6% (9)
Current smoker	13.4% (26)
Current use of oral contraceptive pills among women	18.3% (24)
Procedure performed	
AVNRT	76.3% (148)
Right-sided accessory pathway ablation	23.7% (46)
Ultrasound-guided venous access	22.2% (43)
Number of sheaths used	
3.0	96.4% (187)
4.0	3.6% (7)
Median hours of compression dressing applied	10 [6–15]
Median hours of postprocedure bed rest advised	4 [2–4]
Median hours of postprocedure bed rest maintained	4 [4–6]

3 | RESULTS

We performed POCUS on 194 patients who underwent right-sided catheter ablation within 24 h of procedure. Average age was 43.5 + 13.2 years and 131 (67.5%) were women. A total of 148 (76.3%) underwent AVNRT ablation. One was a re-do procedure (recurrence of AVRT caused by right-sided accessory pathway). Mean BMI was 26.0 Kg/m^2. Two 6F and one 7F sheaths were used in 96.4% of patients. Heparinized saline for flushes was used in all patients. Sheaths were removed with aspiration at the end in 25.3%. Mean duration of compression dressing applied was 11.4 h. On the average of 3.3 h (range 2–6 h), bed rest was advised but many patients stayed in bed for a longer time so the average bed rest was actually 4.8 h as shown in Table 1.

Ten (5.2%) patients (nine sub-clinical) developed DVT in the cannulated lower extremity as shown in Figure 1 as well as in videos 1 and 2 in supplementary data. No DVT was identified in the control limb. DVT was seen more frequently in age group (>53 years) compared to patients under 53 years (10% vs. 3% $p = 0.041$). DVT was also more common in women (6.1%) compared to men (3.2%), but did not reach clinical significance. No relationship was found with use of oral contraceptive pills or smoking. Mean duration of procedure in patients without and with DVT (58.66 min vs. 79.9 min) is included, although there is difference in mean duration in both groups, but we assume that as a result of small number of events, it did not reach clinical significance.

Among modifiable procedural factors, DVT was associated with greater number of sheaths and duration of bed rest. Eight of 187 (4.3%) patients with three sheaths developed DVT, while 2 out of 7 patients (28.6%) with four sheaths developed DVT ($p = 0.004$). Duration of bed rest was longer in DVT group compared to patients who did not develop DVT (bed rest maintained up to 4.0 h vs. >4.0 h, $p = 0.006$) as shown in Table 2 and Figure 2.

4 | DISCUSSION

EP study and RFA are standard of care in the diagnosis and treatment of supra-ventricular tachycardia.[13] Although RFCA has a low complication rate, the occurrence of DVT cannot be ignored. Venous thromboembolism (VTE), which includes both DVT and pulmonary embolism (PE), has a mortality rate of 6% to 12%.[14] Ninety-day mortality rate with asymptomatic proximal DVT was found to be 13.75%[10] in literature. A previous study showed the incidence of asymptomatic DVT following catheter ablation at 10%.[5] Our study showed a lower but nonetheless clinically important incidence of 5.2%. Identification of factors that may contribute to DVT formation

TABLE 2 Incidence of DVT by demographic and clinical characteristics after right-sided catheter ablation.

		DVT status		
	Total (N)	No DVT	DVT	*p*-value
Total (*N*)	194	94.8% (184)	5.2% (10)	–
Gender				
Male	63	96.8% (61)	3.2% (2)	0.387
Female	131	93.9% (123)	6.1% (8)	
Mean age (years)	194	43.4 ± 13.1	45.4 ± 16.2	0.645
≤53 years	132	96% (128)	3% (4)	0.040
>53 years	62	90% (56)	10% (6)	
Median body mass index (kg/m^2)	194	26 [22.9–28.1]	26.6 [23–28.8]	0.777
Smoking status				
Never smoked	159	93.7% (149)	6.3% (10)	0.313
Ex-smoker	9	100% (9)	0% (0)	
Current smoker	26	100% (26)	0% (0)	
Current use of oral contraceptive pills among women				
No	107	93.5% (100)	6.5% (7)	0.550
Yes	24	95.8% (23)	4.2% (1)	
Procedure performed				
AVNRT	148	95.9% (142)	4.1% (6)	0.214
Right-sided accessory pathway ablation	46	91.3% (42)	8.7% (4)	
Number of sheaths used				
3.0	187	95.7% (179)	4.3% (8)	0.004
4.0	7	71.4% (5)	28.6% (2)	
Sheath removal with aspiration at the end				
No	145	94.5% (137)	5.5% (8)	0.694
Yes	49	95.9% (47)	4.1% (2)	
Median hours of compression dressing used after dressing removed	194	10 [6–15]	14 [10–24]	0.115
Median hours of postprocedure bed rest advised	194	4 [2–4]	4 [4–4]	0.037
Median hours of postprocedure bed rest maintained	194	4 [4–6]	5 [4–8]	0.177
Up to 4 h	132	97.7% (129)	1.5% (2)	0.006
More than 4 h	62	87% (54)	12.9% (8)	
Mean duration of procedure (minutes)	194	58.66	79.9	0.159

can allow us to modify our practice to mitigate the risk of developing DVT.

Increased number of sheaths and prolonged compression dressing likely obstruct blood flow and provide ground for DVT development which is borne out by our study.

Prolonged bed rest is well known to promote DVT but our study shows that even short bed rest (less than 7 h) affected DVT development in the instrumented limb. Interestingly, no patient developed DVT in the control limb showing that limbs or patients who have not had venous cannulation are unlikely to develop DVT with this duration of bed rest.

Currently, there are no guidelines or consensus documents regarding optimal bed rest duration postprocedure. Our study concluded that decreasing bed rest duration may decrease incidence of DVT.

Our study supports the finding that advancing age enhances the risk of DVT formation. Extra care needs to be paid to this group. Shorter bed rest and decreasing application of compression dressing should be especially applied in older patients as they are more prone to DVT development and perhaps DVT prophylaxis postprocedure can be considered.

Ninety percent of the DVTs in our study were sub-clinical. Subclinical DVTs carry a significant risk of out-of-hospital morbidity and mortality if they remain undetected.[10] Very little data on this potentially catastrophic complication exists. Our study along with a previous study on the subject shows that these numbers warrant more concern. Departmental ultrasounds to screen all postprocedure patients may be prohibitive in terms of procedure cost as well as logistically organizing it in a timely fashion as most patients stay less than 24 h post-RFA. POCUS is an easily available tool and EP

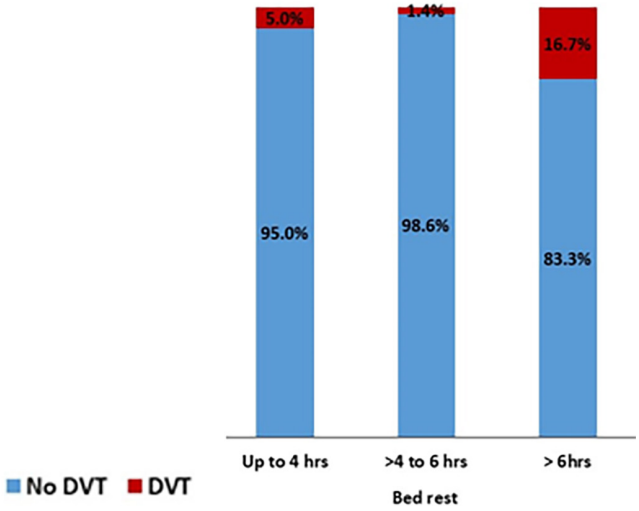

FIGURE 2 Relationship between bed rest and DVT incidence.

team members can be easily trained to use it for DVT detection. ER physicians were able to screen for DVTs with POCUS with accuracy of 93.1% compared to studies performed in radiology departmental suites.[15] In our study, we observed that after the initial 30 patient POCUS screening study of the cannulated limb added approximately 6 min to the predischarge evaluation.

Currently, there are no guidelines or consensus documents regarding optimal DVT prophylaxis after right-sided RFA. Standard postoperative DVT preventive measures such as early mobilization, compression stockings, anticoagulant therapy, muscle movement, and optimal hydration can be used, but none were implemented in our study.

EHRA survey reported that intravenous heparin is adopted by 37% of electrophysiologists after right-sided RFA, while VTE prophylaxis is adopted by 25% of electrophysiologists after discharge, and the type of VTE prophylaxis is heterogeneous; among operators who prescribe VTE prophylaxis, the majority (71%) give aspirin.[6]

Based on our study we suggest using fewer sheaths and shorter duration of bed rest to mitigate the risk of DVT post-RFA. Moreover, use of POCUS for screening these patients should be considered routinely. POCUS is a cost-effective modality for vascular access and avoiding complications. It is a long-term economically viable option even in resource-limited settings.[16] Further studies on the utility and cost effectiveness of this approach can be done to develop formal recommendations for this.

5 | CONCLUSION

DVT is not uncommon with an incidence of 5.2% post-right-sided RFA.

Age (≥53 years), greater sum of sheaths used, and longer maintenance of postprocedural bed rest were associated with DVT incidence.

POCUS can be used to effectively detect DVTs with postprocedure predischarge screening.

With DVT incidence of 5.2%, we will need to screen only 20 patients to detect one DVT.

5.1 | Study limitations

1. Absence of preprocedural ultrasound.
2. The study excluded the patients who are probably at high risk of developing DVT such as those with periprocedural complications, postprocedure bleeding, intubated and ventilated patients, previous ablation within 6 months, as well as with known malignancy.
3. Variable protocols were used for duration of bed rest (ranging from 2 to 6 h) and application of compression dressing after RFCA procedures.
4. Maintained bed rest was different from advised bed rest.

ACKNOWLEDGMENTS

We thank Mr. Musa Karim (Statistician Research Department) at the National Institute of CardioVascular Diseases, Karachi, Pakistan, for his assistance with data analysis.

CONFLICT OF INTEREST STATEMENT

Authors declare no conflict of interests for this article.

DATA AVAILABILITY STATEMENT

We declare data availability if required.

ETHICS APPROVAL

Our study was conducted after getting Institutional Ethical Review Committee approval (ERC=056/2022) and our manuscript is not published elsewhere.

PATIENT CONSENT

Written and informed consent is taken from every participant before performing ultrasound scan.

ORCID

Reema Qayoom https://orcid.org/0009-0009-2989-0215
Ghazala Irfan https://orcid.org/0000-0003-0379-6000

REFERENCES

1. Davutoglu V, Kervancioglu S, Dinckal H, Soydinc S, Turkmen S, Akdemir I, et al. High incidence of occult femoral vein thrombosis related to multiple venous sheaths during electrophysiological studies. Heart. 2004 Sep 1;90(9):1061–2.
2. Li L, Zhang BJ, Zhang BK, Ma J, Liu XZ, Jiang SB. Prevention and treatment of lower limb deep vein thrombosis after radiofrequency catheter ablation: results of a prospective active controlled study. Sci Rep. 2016 Jun 22;6(1):28439.
3. Moubarak G, Bonhomme S, Vedrenne G, Bouleti C, Ollitrault J, Priollet P, et al. Femoral vein thrombosis after right-sided electrophysiological procedures. J Interv Card Electrophysiol. 2013 Dec;38:155–8.

4. Bruce C, Rogers S, Saraf K, Kirkwood G, Kirkland N, Wright M, et al. P1450 deep vein thrombosis after right sided catheter ablation; more common then previously thought? EP Europace. 2020 Jun 1;22(Supplement_1):euaa162-324.
5. Chen JY, Chang KC, Lin YC, Chou HT, Hung JS. Safety and outcomes of short-term 7 multiple femoral venous sheath placement in cardiac electrophysiology study and 8 radiofrequency catheter ablation. Jpn Heart J. 2004;45:257–64.
6. Mugnai G, Farkowski M, Tomasi L, Roten L, Migliore F, de Asmundis C, et al. Prevention of venous thromboembolism in right heart–sided electrophysiological procedures: results of an European Heart Rhythm Association survey. Europace. 2024 Jan;26(1):euad364.
7. Joseph JP, Rajappan K. Radiofrequency ablation of cardiac arrhythmias: past, present and future. QJM. 2012;105:303–14.
8. Hindricks GO. Multicentre European Radiofrequency Survey (MERFS) investigators of the Working Group on Arrhythmias of the European Society of Cardiology. The Multicentre European Radiofrequency survey (MERFS): complications of radiofrequency catheter ablation of arrhythmias. Eur Heart J. 1993 Dec 1;14(12):1644–53.
9. Burstein B, Barbosa RS, Kalfon E, Joza J, Bernier M, Essebag V. Venous thrombosis after electrophysiology procedures: a systematic review. Chest. 2017 Sep 1;152(3):574–86.
10. Vaitkus PT, Leizorovicz A, Cohen AT, Turpie AG, Olsson CG, Goldhaber SZ, et al. Mortality rates and risk factors for asymptomatic deep vein thrombosis in medical patients. Thromb Haemost. 2005;93(1):76–9.
11. Zuker-Herman R, Ayalon Dangur I, Berant R, Sitt EC, Baskin L, Shaya Y, et al. Comparison between two-point and three-point compression ultrasound for the diagnosis of deep vein thrombosis. J Thromb Thrombolysis. 2018 Jan;45:99–105.
12. Ortel TL, Neumann I, Ageno W, Beyth R, Clark NP, Cuker A, et al. American Society of Hematology 2020 guidelines for management of venous thromboembolism: treatment of deep vein thrombosis and pulmonary embolism. Blood Adv. 2020 Oct 13;4(19):4693–738.
13. Brugada J, Katritsis DG, Arbelo E, Arribas F, Bax JJ, Blomström-Lundqvist C, et al. 2019 ESC guidelines for the management of patients with supraventricular tachycardia the task force for the management of patients with supraventricular tachycardia of the European society of Cardiology (ESC) developed in collaboration with the association for European paediatric and congenital Cardiology (AEPC). Eur Heart J. 2020 Feb 1;41(5):655–720.
14. Wilbur J, Shian B. Diagnosis of deep venous thrombosis and pulmonary embolism. Am Fam Physician. 2012 Nov 15;86(10):913–9.
15. Spampinato MD, Luppi F, Cristofaro E, Benedetto M, Cianci A, Bachechi T, et al. Diagnostic accuracy of Point Of Care UltraSound (POCUS) in clinical practice: a retrospective, emergency department based study. J Clin Ultrasound. 2023 Dec 7;52:255–64.
16. Varrias D, Palaiodimos L, Balasubramanian P, Barrera CA, Nauka P, Arfaras-Melainis A, et al. The use of point-of-care ultrasound (POCUS) in the diagnosis of deep vein thrombosis. J Clin Med. 2021 Aug 30;10(17):3903.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Qayoom R, Asghar HS, Lutfi IA, Qadir F, Irfan G, Shafquat A. Using point-of-care ultrasound to determine incidence of deep vein thrombosis after right-sided radiofrequency catheter ablation. J Arrhythmia. 2024;40:1131–1136. https://doi.org/10.1002/joa3.13111