REVIEW ARTICLE

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ULTRASOUND AS A SCREENING TOOL FOR EARLY DIAGNOSIS OF DEEP VENOUS THROMBOSIS IN HOSPITALIZED PATIENTS

CAROLINA DE ARAÚJO MACHADO [1], ANA LUIZA AGUIAR ÁVILA [1], ARIELA MAULLER VIEIRA PARENTE [2], AMANDA VIEIRA PARENTE[3], FÁBIO VECCHINI MARTINS [4], WALDEMAR NAVES DO AMARAL [5]

ABSTRACT

INTRODUCTION: Deep vein thrombosis (DVT) of the lower limbs is a serious vascular disease where accurate diagnosis and treatment are crucial to prevent embolization and other complications. Point-of-care ultrasound (POCUS), an ultrasound examination performed at the bedside, has been increasingly used due to its diagnostic accuracy comparable to other radiological exams in the diagnosis of DVT.

OBJECTIVE: To assess the application of POCUS in hospitalized patients for the diagnosis of DVT, observing its sensitivity and specificity.

METHODOLOGY: Narrative review in the PubMed database, considering eligible articles in English, from 2018 to 2024, with information about POCUS with two and three-point compression, with data that allows analyzing if it is a method with good sensitivity and specificity.

RESULTS: Five eligible articles were selected for consideration in this review if they reported the use of POCUS in the diagnosis of DVT. The sensitivity of POCUS in detecting DVT ranged from 82.8% to 100%, and the specificity ranged from 90% to 98.8%. The positive predictive value ranged from 61.5% to 83%, while the negative predictive value ranged from 97% to 100%.

CONCLUSION: It is evident that POCUS presents excellent effectiveness in addition to being low cost and easy to perform. The time from examination to DVT diagnosis is shorter compared to other methods, favoring the anticipation of antithrombotic therapy and improving morbidity and mortality.

KEYWORDS: POCUS, DEEP VEIN THROMBOSIS, HOSPITALIZED PATIENTS.

INTRODUCTION

Acute deep vein thrombosis (DVT) of the lower limbs is a serious vascular disease with an annual incidence of 0.1% in adults. Accurate diagnosis and treatment of acute DVT are crucial to prevent embolization and other complications. Mortality from pulmonary embolism, a potentially fatal complication of DVT, can reach 30% if left untreated[1].

While the gold standard for diagnosing DVT is contrast venography, ultrasound is a good diagnostic alternative, especially when considering other diagnostic methods such as clinical diagnosis, D-dimer, Wells and Geneva scores, due to its wide availability, cost-effectiveness, absence of radiation, absence of intravenous contrast, and patient comfort [1, 2].

Point-of-care ultrasound (POCUS), an ultrasound examination performed and interpreted by the physician at the bedside, has been increasingly used in the emergency department, intensive care unit (ICU), wards, and outpatient settings for evaluating the venous system of the lower limbs. Studies have found that POCUS can have diagnostic accuracy comparable to other radiological exams, making it a very useful tool in routine clinical practice1.

The American College of Emergency Physicians has supported the use of POCUS to assess DVT since the 1990s, but it was only in 2017 that DVT was added to the list of twelve main ultrasound applications for emergency medicine[1].

DVT still poses a challenge regarding diagnosis, treatment, and follow-up. Vascular ultrasound has been shown to be necessary for establishing the diagnosis, the type of thrombosis, and the appropriate treatment course. When the criteria are accurately met, they lead to the diagnosis of DVT, early initiation of treatment, and establishment of the ideal strategy after the initial treatment period[3].

METHODOLOGY OF THE POCUS EXAM

Patient Position

Initially, it is necessary to clarify the techniques applied in performing POCUS in the lower limbs for research and possible detection of DVT in patients. There are two types of POCUS techniques used, the two-point compression and three-point compression. The two-point POCUS evaluates

1. Universidade de Rio Verde - Rio Verde GO.
2. Universidade do Planalto Central – Uniceplac.
3. Universidade Alfredo Nasser – Unifan Goiânia GO.
4. Faculdade Zarns - Itumbiara GO.
5. Universidade Federal de Goiás – UFG Goiânia GO.

MAILING ADDRESS:
CAROLINA DE ARAÚJO MACHADO
Endereço: Rua 30, nº 224, Setor Marista
Edifício Âme Infinity Home - Goiânia GO
E-mail: carolaraujomachado@gmail.com

the compressibility of the common femoral vein (CFV) and popliteal vein, and the three-point POCUS includes the superficial femoral vein (SFV)[3].

To perform the ultrasound examination of the veins of the lower extremity, the patient should lie on their back, with the head elevated at an angle of preferably 30°. This inclination helps to prevent the accumulation of blood in the leg veins and facilitates the visualization of the blood vessels[3].

Next, the examiner should externally rotate the patient's hip and slightly bend the knee. This position is most commonly used as it enlarges the femoral veins and brings them closer to the ultrasound transducer's field of view. Additionally, the position allows for examination of the inguinal region and popliteal fossa without the need to reposition the patient. When possible, the prone position can be useful for examining the popliteal veins[3].

The examiner usually stands beside the patient, on the same side as the extremity being evaluated. If using a ultrasound machine mounted on a cart, it should be positioned within reach of the examiner at the head of the bed. The bed height should be adjusted for the comfort of the examiner[3].

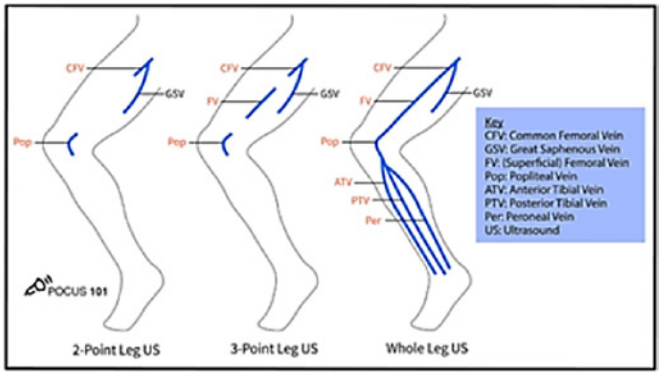

Figure 1: Vessels analyzed in lower limb ultrasound types. POCUS, 2022[5].

Description of the techniques:

Correct vein compression: apply pressure until the pulsatile artery is slightly compressed, if the adjacent vein compresses completely, there is no DVT.

Figure 2: Example of artery and vein visualized without and with compression. POCUS, 2022[5].

Step 1: Femoral Vein

• With gel on the transducer, place it along the inguinal ligament, between the pubic symphysis and the anterior superior iliac spine (ASIS).

• Position the transducer perpendicular to the skin, in the transverse direction.

• Locate the common femoral vein (CFV) and common femoral artery (CFA).

• Note that the CFV is medial to the CFA.

• Apply firm pressure with the transducer until the artery is slightly compressed. In a normal scan, the vein should be fully compressed [4, 5].

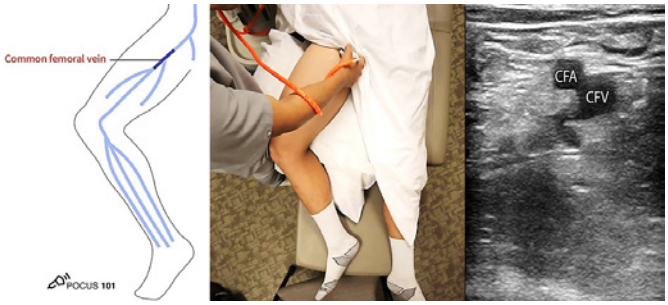

Figure 3: Visualization of the common femoral artery and common femoral vein without compression. POCUS, 2022[5].

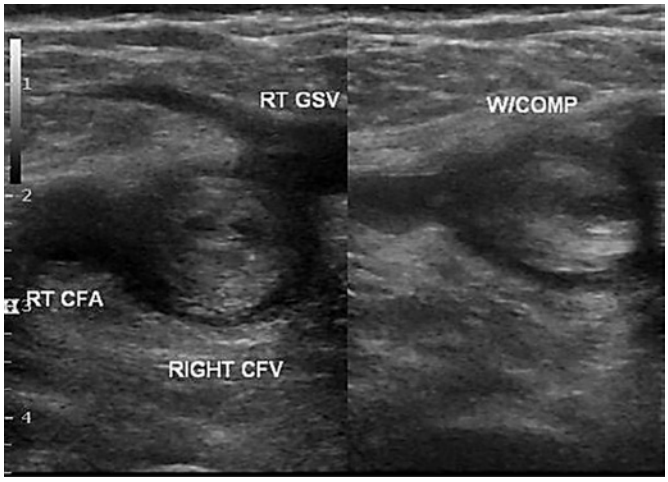

Figure 4: Example of common femoral vein with thrombus (without and with compression). POCUS, 2022 [5].

Step 2: Great Saphenous Vein

• Slide the transducer 1-2cm down the patient's leg to find where the great saphenous vein branches off from the CFV.

• As the transducer moves distally, the artery typically bifurcates first, followed by the vein.

• Compress the CFV at the junction with the great saphenous vein.

• Depending on the size and proximity of a clot in the great saphenous vein with the CFV, there is evidence that these should also be treated as DVT [4, 6].

Figure 5: Visualization of the branching of the great saphenous vein and common femoral vein. POCUS, 2022 [5].

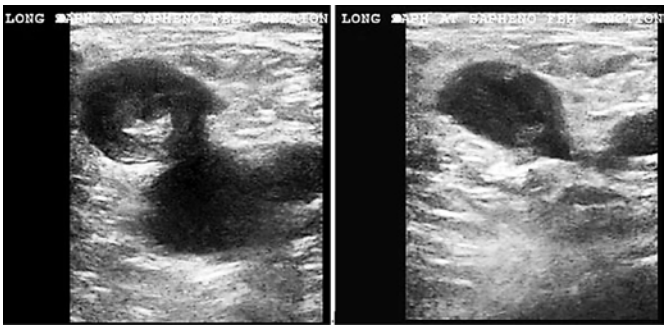

Figure 6: Example of thrombus in the great saphenous vein at the junction with the common femoral vein (without compression and with compression) [6].

Step 3: Femoral Vein (Superficial)
• Slide the transducer 1-2cm down the patient's leg to find where the CFV branches into the deep and superficial femoral veins.
• The deep femoral vein will dive deeply into the thigh. The superficial femoral vein will run alongside the femoral artery.
• Compress the superficial femoral vein immediately distal to the bifurcation.
• Optional: although the three-point ultrasound protocol requires compression just distal to the bifurcation, you may also check for clots in the remainder of the superficial femoral vein by gradually moving the transducer downward and medially toward the popliteal fossa where the superficial femoral vein dives into the adductor canal[4, 5].

Figure 7: Visualization of the femoral artery and superficial femoral vein. POCUS, 20225.

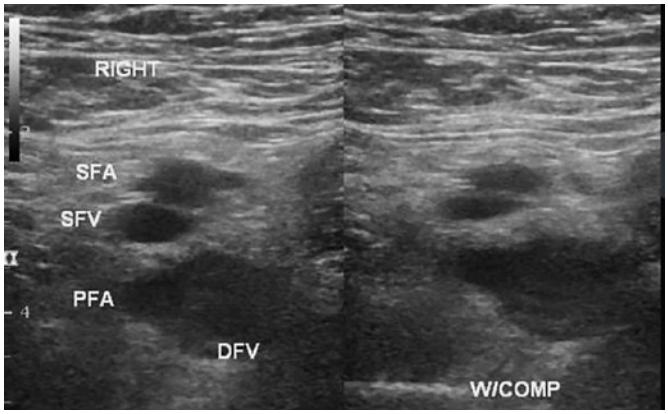

Figure 8: Example of superficial and deep femoral veins with thrombus (without and with compression). POCUS, 2022[5].

Step 4: Popliteal Vein
Step 3: Femoral Vein (Superficial)
• Move the transducer to the posterior fold of the knee and slide 2cm above and below to find the popliteal vein.
Step 3: Femoral Vein (Superficial)
• Locate the popliteal vein by placing the transducer directly between the two hamstring tendons, behind the knee. Use the transducer to compress the popliteal vein and check for clots.
Step 3: Femoral Vein (Superficial)
• Note in the visualization that the popliteal vein is now at the top and the popliteal artery is at the bottom[4, 5].

Figure 9: Visualization of the popliteal artery and popliteal vein. POCUS, 2022[5].

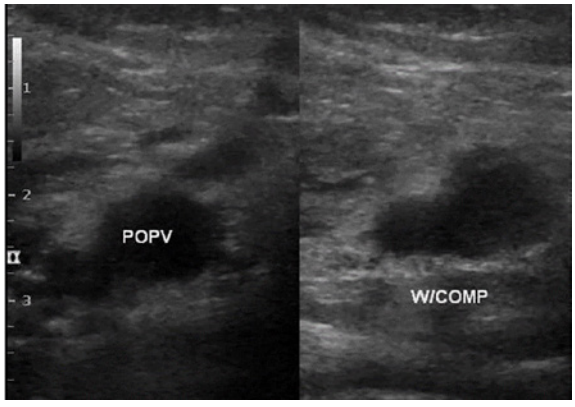

Figure 10: Example of popliteal vein with thrombus (without and with compression). POCUS, 2022[5].

Step 5: Trifurcation of the Popliteal Vein
• Continue scanning slightly more distal to the popliteal vein to find its trifurcation.
• Compress the popliteal vein until you find where it trifurcates into the anterior tibial, fibular, and posterior tibial veins.
• This junction signals the end of the exam[4].

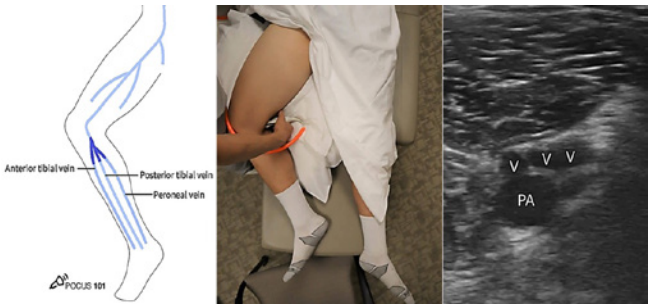

Figure 11: Visualization of the trifurcation of the popliteal vein (where the exam ends). POCUS, 2022[5].

In all POCUS techniques, the diagnosis of DVT is made by visualizing an echogenic clot or an area of the vein that cannot be fully compressed. Acute venous thrombosis usually results in the non-compressibility of a vein before an echogenic clot can be visualized. When testing the compression of a vein, the examiner should apply enough pressure so that the nearby pulsatile artery is slightly compressed. The pressure should be applied quickly and perpendicular to the vein with the transducer in a transverse orientation. Weak compression can result in a false-positive result. Rarely, too much compression can result in a false-negative result.[1].

OBJECTIVE

Evaluate the application of POCUS in hospitalized patients for the diagnosis of DVT, observing the sensitivity and specificity of the method found in each of the studies.

MATERIALS AND METHODS

A narrative review was conducted, considering eligible studies for this review those that reported the use of POCUS in the diagnosis and treatment of DVT. Studies published in English, conducted between 2018 and 2023, with information on POCUS with two and three-point compression, were included. The data allowed for an analysis of whether it is a method with good sensitivity and specificity in the evaluation of DVT in hospitalized patients.

The Pubmed databases were searched between August 20th and September 20th, 2023. A combination of free text words and MeSH terms was used, including the terms: POCUS, diagnosis, deep vein thrombosis, hospitalized, and patients.

Filters used: Free full text, last five years, and Case Reports, Clinical Study, Clinical Trial, Comparative Study, Multicenter Study, Observational Study, Case Reports, Clinical Study, Clinical Trial, Comparative Study, Multicenter Study, Observational Study and review.

138 articles were found, applying the publication year filters, 38 articles remained, of which only 28 met the selection criteria, describing the sensitivity and specificity of the method, for abstract reading. Afterwards, nine articles were read in full and five selected for data analysis (see flowchart - figure 12).

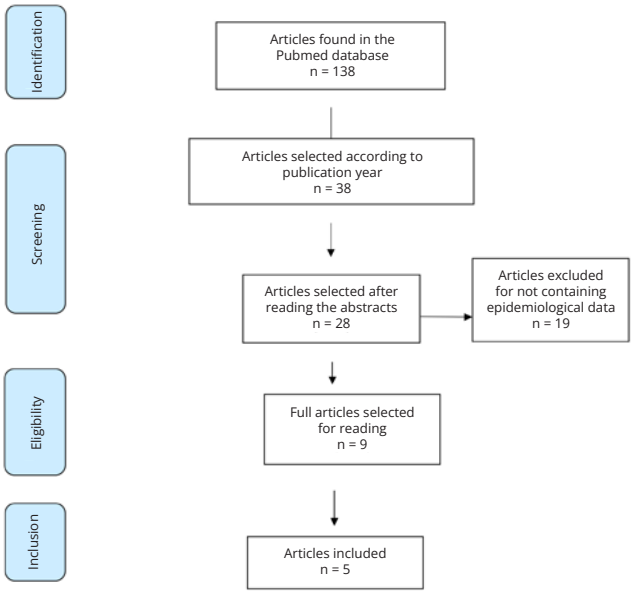

Figure 12: Flowchart of study selection

RESULTS

Analyzing all these studies, the sensitivity of POCUS in detecting DVT ranged from 82.8% to 100%, and the specificity ranged from 90% to 98.8%. The positive predictive value ranged from 62% to 83%, and the negative predictive value ranged from 97% to 100%. Both two-point and three-point POCUS techniques demonstrated comparable performance in the diagnosis of DVT, being highly effective (see Table 1).

Autor	Nº	Sens (%)	Espec (%)	VPP(%)	VPN(%)	Falso negativo(%)
Lee et al., 2019	195	Pocus 2: 91	Pocus 2: 98			Pocus 2: 4.0
		Pocus 3: 90	Pocus 3: 95			Pocus 3: 4.1
Zuker-Herman et al., 2018	266	Pocus 2: 82,8	Pocus 2: 98,5			
		Pocus 3: 90,6	Pocus 3: 98,5			
Canakcib et al., 2020	73	100	95,8	61,5	100	
Fischer et al., 2019	1337	93	93	83	97	

Table 1: Distribution of studies according to the number of patients evaluated by the study, sensitivity (sens), specificity (spec), positive predictive value (PPV), negative predictive value (NPV), author and year of publication, false negative.

DISCUSSION

POCUS is a method that is gaining increasing prominence in the diagnosis of DVT. Interest in the use of this method has grown substantially, not only in emergency medicine and intensive care, but also in internal medicine and hospital medicine[3].

Considering other diagnostic methods, such as clinical diagnosis, there is low sensitivity and specificity, with confirmation in 20-40% of patients with suggestive symptoms. D-dimer, despite high sensitivity (around 95%), has low specificity (40%), as several other clinical conditions can cause its elevation, such as inflammation, myocardial infarction, active cancer, stroke, pregnancy, and old age. However, a high negative predictive value is observed in suspected DVT cases. Scores that can be used to assess the probability of DVT, such as the Wells Score, have shown sensitivity between 64-79%, and specificity between 49-90%. In the Geneva score, sensitivity ranged from 55-74%, and specificity from 49-90%. The high probability of PTE in the aforementioned diagnostic methods can be confirmed by applying POCUS[2].

A meta-analysis conducted by researchers from the emergency and radiology departments at university hospitals in Korea compared results obtained from the evaluation of patients with suspected DVT using two-point and three-point compression POCUS. The researchers reviewed 17 studies in 16 original articles that included patients undergoing two-point POCUS (1337 patients in nine studies) and three-point POCUS (1035 patients in eight studies). Two-point POCUS showed a sensitivity of 91% (95% CI, 0.68-0.98) and specificity of 98% (95% CI, 0.96-0.99). Three-point compression POCUS achieved a sensitivity of 90% (95% CI, 0.83-0.95) and specificity of 95% (95% CI, 0.83-0.99). Overall, the performance of both POCUS methods was similar, with similar sensitivity and specificity rates, and the rates of false negatives in two-point and three-point compression POCUS were very close, 4.0% and 4.1% respectively [7].

A study conducted with 195 patients at the Rabin Medical Center-Beillinson Hospital in Israel was able to correctly diagnose DVT through two-point POCUS in 79% of patients with positive findings on traditional radiological methods and had a false-positive rate of 1.5% in patients without DVT. It showed a sensitivity of 82.8% and specificity of 98.8%. On the other hand, using three-point POCUS, the rate of correct diagnoses of DVT in hospitalized patients was 90%, with the same false-positive rate (1.5%). It had a sensitivity of 90.6% and specificity of 99%. In this study, the sensitivity of three-point compression POCUS was significantly higher than that of two-point POCUS ($p < 0.001$), and the specificity was similar in both methods[8].

Members of the emergency department and biostatistics departments at Eskisehir Osmangazi University and Yildirim Beyazit University Yenimahalle Training And Research Hospital, both in Turkey, conducted a study using two-point compression POCUS. They examined 266 patients, of whom 68 were diagnosed with DVT. 93% of these were detected through POCUS, showing a sensitivity of 93% (95% CI, 84-98) and specificity of 93% (95% CI, 89-96). The positive predictive value (PPV) was 83% and a negative predictive value (NPV) of 97% in this study[9]. These results support the usefulness of POCUS as a valuable tool in the emergency department for the initial evaluation of patients with suspected DVT, allowing for a rapid diagnosis and timely management. The use of gold standard reference tests increases the validity of the study results[9].

Another study conducted by the University of Minnesota, MedStar Georgetown, Health Partners/Regions, and Cincinnati Medical Center also compared the results of POCUS use by trained professionals with diagnosis by radiologist-interpreted exams, evaluating the lower limbs of 73 hospitalized patients in wards with a high pre-test probability of DVT. The results showed that hospitalist professionals achieved a sensitivity of 100% and a specificity of 96% in detecting DVT using POCUS, with positive and negative predictive values of 62-100%, respectively. Additionally, the average time from request to completion of POCUS was significantly shorter than the average time from request to finalization of the radiology report, with a difference of 5.7 hours between the completion of both exams. It was concluded that hospitalists from various specialties, when trained, are capable of performing POCUS for DVT with accuracy similar to radiologists, and the results are available more quickly than with the radiology team. POCUS has proven to be a good method for ruling out DVT. However, additional studies are needed to determine how to incorporate POCUS in the case of positive DVT exams in clinical practice.

A study at a general hospital in Spain, using three-point POCUS in 109 patients with suspected DVT, compared the results with Doppler ultrasound performed by radiologists afterward. Of these patients, 60 were found to have DVT by POCUS, and of these, 55 were confirmed by Doppler ultrasound, resulting in a sensitivity of 93% (95% CI, 83.8-97.3%) and specificity of 90% (95% CI, 78.6-95.7%), with an accuracy of 92% (95% CI, 85-95.6%). This indicates that emergency physicians can achieve a level of competence similar to that of radiologists in performing these exams, but substantial training and practice are necessary to achieve and maintain this performance. It is important for professionals to be aware of their limitations and to stay updated on ultrasound applications.[11].

CONCLUSSION

Based on the studies evaluated on the application of POCUS in the diagnosis of deep vein thrombosis (DVT), it is evident that this technique has excellent effectiveness, low cost, and easy implementation. The time taken to perform the exam and reach a diagnosis of DVT is significantly shorter compared to other methods, favoring the early initiation of antithrombotic therapy and improving morbidity and mortality.

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CAROLINA DE ARAÚJO MACHADO
http://lattes.cnpq.br/4555365272429434
https://orcid.org/0000-0001-6318-4159

ANA LUIZA AGUIAR ÁVILA
http://lattes.cnpq.br/8377102914291354
https://orcid.org/0000-0002-7728-7551

ARIELA MAULLER VIEIRA PARENTE
http://lattes.cnpq.br/0780896170758778
https://orcid.org/0000-0001-8353-833X

AMANDA VIEIRA PARENTE
http://lattes.cnpq.br/8284453419124489
https://orcid.org/0009-8266-740X

FÁBIO VECCHINI MARTINS
http://lattes.cnpq.br/5729759144444722
https://orcid.org/0009-0000-1103-997X

WALDEMAR NAVES DO AMARAL
http://lattes.cnpq.br/4092560599116579
https://orcid.org/0000-0002-0824-1138

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