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Accuracy of Ultrasound Identifying Femoral Deep Vein Thrombosis by Anesthesia Trainees after a Brief Training Program

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ABSTRACT

Background: Deep vein thrombosis and pulmonary embolism pose significant risks for morbidity and mortality, and while clinical diagnosis, D-dimer tests, and Computerized tomogram venography are commonly used, they each have their own drawbacks. The use of bedside ultrasound conducted by non-radiologists is emerging as a promising approach for diagnosis, offering effectiveness with varying levels of training required.

Aims: The study seeks to determine the impact of a brief, focused educational module on the proficiency of anesthesia trainees in using ultrasound for the detection of femoral Deep vein thrombosis through compression method.

Methods: This observational comparative study took place at a tertiary teaching hospital between August 1st and December 1st, 2023. It involved 70 patients who were bedridden for a minimum of three days across different hospital departments. The screening, which focused on the femoral veins, was conducted by three anesthesia trainees who had undergone a short training course. Their findings were then compared with those of an expert.

Results: Nine cases of femoral deep venous thrombosis were accurately detected by the three study operators using compression ultrasonography, consistent with the findings of the reference operator. In two instances, patients with a negative finding exhibited reduced venous compression as identified by one or more study operators. The sensitivity and specificity of the trainees were found to be 100% and 98%, respectively.

Conclusion: Short, focused educational module sufficiently is adequate to enhance the proficiency of anesthesia trainees in using ultrasound for the detection of femoral deep vein thrombosis through the compression method, leading to high accuracy and comparative performance.

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INTRODUCTION

DVT is a major health problem, affecting approximately 1-2 per 1000 individuals annually. The annual incidence rate of PE was reported to vary widely, with a range from 0.039 per 1000 people in Hong Kong to 1.15 per1000 in the United States.[1]

Nearly 75% of all deaths related to venous thromboembolism (VTE) occurred due to VTE acquired in hospitals. In the European Union, VTE represents a significant health issue, with more than one million events or deaths occurring annually across six countries studied.[2]

Mortality in VTE is strongly linked to older age, cancer, heart disease, serious illness, surgery, or trauma. Swift diagnosis and treatment are vital, particularly for high-risk patients. It occurs when part of the thrombus breaks off and travels to the lungs and is fatal in 5-10% of cases. PTS, a chronic complication caused by damage to venous valves, occurs in 20-50% of DVT patients and severely impacts quality of life. Overall, the 30-day all-cause mortality rate for patients with DVT is approximately 6%.[3]

The rate of VTE is significantly higher in patients with femoral DVT, approximately 50%, compared to those with

calf DVT, which is around 18%. That is why it is crucial to promptly identify and treat DVT in the femoral region. Femoral DVT, making up about 20% of lower extremity DVT cases, significantly contributes to proximal lower extremity thrombosis.[4]

Relying solely on clinical evaluation is not dependable, since up to 75% of DVT cases can occur without any symptoms. Risk factors like recent surgery heighten DVT suspicion, yet its confirmation is elusive, with symptoms like leg pain absent in many cases.[4]

Traditionally, the diagnosis has relied on radiologic and laboratory tests, which have notable limitations. For example, the D-dimer assay, while sensitive, is not specific and prone to false positives and shows elevated levels in various patient groups without thrombosis, highlighting the importance of clinicians tests for a more quick or precise diagnosis.[5]

The CT venography, while precise in diagnosing DVT, is an expensive test that subjects' patients to significant levels of radiation. The CT scans can also present risks for people with renal impairments because of the potential for contrast nephropathy.[6]

The adoption of ultrasound performed by clinicians has been demonstrated to decrease the frequency of CT scans being used to evaluate DVT. Ultrasound eliminates the hazards linked with contrast venography and CT radiation, while reducing reliance on costly radiological procedures, making it optimal for initial femoral DVT assessments.[7]

Research indicates a notable decline in the use of venography following the training of clinicians in POCUS for DVT diagnosis. Consequently, this shift has led to a reduction in invasive procedures and associated complications.[5]

The POCUS for DVT, when conducted by non-radiologists, demonstrates both high sensitivity and specificity. These scans are typically completed within 24 hours upon request, quicker than traditional departmental scans.

Furthermore, only a little experience is required to achieve accurate results, offering significant time savings in both ambulatory and internal medicine environments.[8]

Proximal compression ultrasound demonstrated high sensitivity (90.1%) and specificity (98.5%) in identifying proximal DVT even when it was carried out by non-radiologists.[9]

Complete duplex ultrasound (CDUS) is recommended for the diagnosis of acute DVT by radiologists, even in the popliteal region. This modality involves compression of deep veins from the inguinal ligament to the ankle and Doppler waveforms in common femoral and popliteal veins. Pooled sensitivity and specificity for CDUS reach to 94% and 97.3%, respectively.[10]

These agreements collectively demonstrate that CUS, including its variants like 3 points CUS and CDUS, can be effective tools with high sensitivity and specificity rates for the diagnosis of femoral DVT.[9]

Moving critically ill patients for radiology is risky and slow, making POCUS a vital alternative for DVT diagnosis.[11]

Traditional evaluations for DVT typically involve tests conducted at multiple intervals, either over 24 or 48 hours, to observe changes over time. This process often leads to delays. However, with the availability of ultrasound technology for immediate use, healthcare professionals have the capability to perform scans on patients as needed clinically. This approach minimizes the necessity for multiple, extensive studies to identify the development of DVT.[12]

Studies show that due to being less time wasting, it cuts down anticoagulation initiation time for acute DVT to mere minutes from hours or days. A typical situation involves patients suspected of having DVT who must wait for official imaging outcomes before beginning anticoagulant treatment and being discharged.[13]

Numerous research studies have indicated that the introduction of ultrasound programs conducted by clinicians leads to shorter hospital stays. Starting treatment directly at the bedside after making diagnoses there enables quicker patient discharge, eliminating the delay for radiology reports. This method benefits both patients and healthcare institutions. Ultrasound performed by clinicians also influences treatment decisions in 25-50% of cases, either by leading to the earlier start of anticoagulation therapy or by avoiding its unnecessary use.[14]

Clinician-operated ultrasound for detecting DVT, while necessitating specific training and equipment, ultimately leads to significant savings in costs. In comparison with the average costs under Medicare nationally, venography is priced at $771, whereas an ultrasound conducted in a radiology department costs $192.[6]

The compression method of ultrasound for detecting femoral vein DVT without using Doppler involves several key steps, utilizing a high-frequency linear transducer typically set between 7mHz and 14mHz:

1. Initial Setup:
   - The transducer is placed along the inguinal ligament, midway between the pubic symphysis and the anterior superior iliac spine (ASIS), with the indicator facing the patient's right to obtain a transverse view.
   - The common femoral vein (CFV) and artery are identified, with the CFV being medial to the common femoral artery (CFA). The probe should be perpendicular to the skin for optimal imaging.
2. Compression Technique: The compression ultrasound is performed by applying firm pressure with the ultrasound probe until the artery compresses slightly. In a normal scan, the vein should compress entirely, indicating the absence of DVT. If the vein does not compress completely, it suggests a possible clot in that region.

3. Sequential Scanning: The scanning procedure entailed applying intermittent compression starting from the area at the inguinal ligament and proceeding downward in intervals of 2-3 cm, covering a total distance of 5-7 cm.
   The leg is positioned in a slight lateral rotation and slight abduction.[15]

Given the reliable sensitivity and specificity and the availability of ultrasound devices, in addition to the high incidence of DVT in the perioperative period, there is a crucial need to investigate the effectiveness of such diagnostic test when performed by anesthesiologists.

Aim of the Study

The study seeks to determine the impact of a brief, focused educational module on the proficiency of anesthesia trainees in using ultrasound for the detection of femoral DVT through compression method.

Patients and methods

A study was conducted at Al Sadr Teaching Hospital in Basra, a tertiary teaching center, from August 1st, 2023, to December 1st, 2023. After the approval by the ethical committee of Iraqi Board of medical Specializations in Anesthesia and Intensive Care. This observational comparative study included 70 bedridden patients, hospitalized for at least three days in various departments. Verbal consent was taken from the patients or their escorts.

The study was carried out by three anesthesia trainees experienced in extended FAST, but not in diagnosing DVT. These trainees completed a brief training course that began with reviewing images and videos. They observed both negative and positive ultrasound identified DVT cases, supervised by an experienced operator. Additionally, they practiced hands-on examinations on at least ten individuals without DVT and one with DVT before starting the study.

The screening involved scanning the femoral veins, starting from the inguinal ligament and extending 5-7 cm downwards using Vscan Air™ SL handheld, wireless linear probe ultrasound imaging system by GE Healthcare 3-12 MHz.

The procedure was meticulously done to prevent dislodging any potential clots. Patients were chosen based on two categories: those without DVT, as determined by the expert, and those with DVT. For patients without DVT, each of the three study operators independently examined the patient's veins in sequence, without knowing if the other operators had already examined the same patient. Each operator then independently reported their findings as negative or positive. These results were then compared to the expert's conclusions for validation. In the case of patients with confirmed DVT by the reference (control) operator, only one of the three operators conducted the examination to minimize the risk of clot disruption and showering. Other parameters taken were D-dimer (only for positive ones), heparin administration and depth of the vein.

Exclusion criteria included:

- Individuals under 16 years of age.
- Those with a femoral vein depth exceeding 3 cm.
- Presence of local infection.
- Burns at the site of examination.
- Pain from any cause.
- Scar on examination sites or individuals with fixed abnormal postures.
- Patient refused.

For the purpose of statistical analysis SPSS software, version 26 was used. Qualitative data were expressed in terms of frequency and percentage, while quantitative data were expressed as mean, standard deviation, median, and minimum and maximum values. To investigate the associations between operator and the ability to make correct diagnosis, Chi2/ Fisher Exact test was used and any probability level below 0.05 was considered significant. To investigate the validity of the junior operators in making the correct diagnosis, sensitivity and specificity rates were measured.

RESULTS

Gender distribution indicates a higher representation of males (71.4%) compared to females (28.6%), with a total of 70 patients.

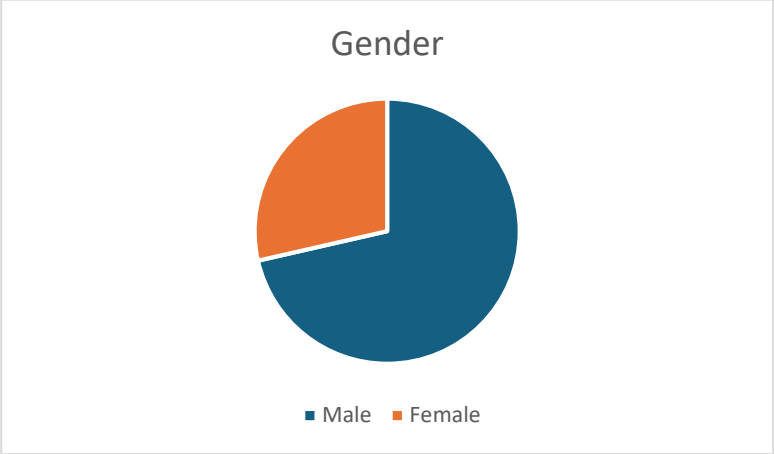

Figure 1: Gender distribution in study.

The age distribution shows a mean age of 57.61 years. The youngest patient in the study is 35 years old, while the oldest is 80 years old, and the standard deviation was 13.995.

Table 1: Comparison between patient taken heparin or not taken.

	No. of Patients	Percent (%)	Positive DVT(No.)
No heparin	30	42.9	5
Heparin	40	57.1	4
Total	70	100	9

The percent of patients who took heparin was 57.1% , while 42.9% did not. Five out of 9 patients developed DVT despite prophylactic heparin administration.

Table 2: the result of D-dimer test of the patient

D-dimer	No. of Patients	Percent
Negative	61	87.1
Positive	9	12.9
Total	70	100

A correlation of 100% is observed between true positive DVT cases and positive D-dimer test outcomes.

Table 3: DVT clinical signs in patients.

DVT clinical signs	No. of patients	Percent (%)
Negative	66	94.3
Positive	4	5.7
Total	70	100

None of the 9 positive DVT cases exhibited positive clinical signs associated with DVT.

Table 4: comparison between first operator and the reference (standard).

		U/S response (standard)		Total	p-Value
		Negative	Positive		
1st operator	Negative	61	0	61	0.0001
		100%	0.0%	100%	
		100%	0.0%	95.3%	
		95.3%	0.0%	95.3%	
	positive	0	3	3	
		0.0%	100%	100%	
		0.0%	100%	4.7%	

		0.0%	4.7%	4.7%	
Total		61	3	64	
		95.3%	4.7%	100%	
		100%	100%	100%	
		95.3%	4.7%	100%	

* Fisher's Exact Test

The 1st Operator: Sensitivity: 100% and Specificity: 100%.

Table 5: comparison between second operator and standard.

		U/S response (standard)		Total	p-Value
		Negative	Positive		
2nd operator	Negative	60	0	60	0.0001
		100%	0.0%	100%	
		98.4%	0.0%	93.8%	
		93.8%	0.0%	93.8%	
	positive	1	3	4	
		25%	75%	100%	
		1.6%	100%	6.3%	
		1.6%	4.7%	6.3%	
Total		61	3	64	
		95.3%	4.7%	100%	
		100%	100%	100%	
		95.3%	4.7%	100%	

* Fisher's Exact Test

(2nd Operator): Sensitivity: 100% and Specificity: 98.36%.

Table 6: comparison between third operator and standard.

		U/S response (standard)		Total	p-Value
		Negative	Positive		
3rd operator	Negative	59	0	59	0.0001
		100%	0.0%	100%	
		96.7%	0.0%	92.2%	
		92.2%	0.0%	92.2%	
	positive	2	3	5	
		40%	60%	100%	
		3.3%	100%	7.8%	
		3.1%	4.7%	7.8%	
Total		61	3	64	
		95.3%	4.7%	100%	
		100%	100%	100%	
		95.3%	4.7%	100%	

* Fisher's Exact Test

(3rd Operator): Sensitivity: 100% and Specificity: 96.72%.

All three operators demonstrated a 100% sensitivity rate with a mean of 98.36% specificity in detecting DVT, aligning with the control's diagnosis in every positive case.

DISCUSSION

This study's results indicate that all three operators have a 100% sensitivity in detecting DVT, matching the control's diagnosis in positive cases. Regarding specificity, two operators demonstrated somewhat lower accuracy, occasionally identifying DVT in cases where the control operator did not confirm its presence, giving an overall specificity of 98%.

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diagnosis in positive cases. Regarding specificity, two operators demonstrated somewhat lower accuracy, occasionally identifying DVT in cases where the control operator did not confirm its presence, giving an overall specificity of 98%.

In confirmed cases of DVT identified by the control operator, it was observed that 5 out of 9 patients were actually receiving heparin treatment.

There is a 100% correlation between true positive DVT cases and positive D-dimer test results in the given dataset. This finding is consistent with the expected utility of the D-dimer test in clinical practice, where a positive D-dimer test is common in cases of DVT, though it is not specific to DVT alone.

Among the 9 true positive DVT cases as confirmed by the reference operator, none showed positive clinical signs of DVT, this suggests that in this specific dataset, clinical signs may not have been a reliable indicator of DVT presence. This could be due to a variety of factors, including the subtlety or absence of symptoms in these particular cases, or variations in the interpretation and reporting of clinical signs.

In a 2022 study, Giordano Tini and his team found that managing DVT in critically ill patients is complex. Their research focused on the effectiveness of ultrasound screening for DVT in ICUs. Findings indicated that such screening not only improved the detection rates of DVT but also avoided excessive treatment.[16]

In a randomized trial, the approach of customizing the length of anticoagulation treatment based on ultrasonography findings was examined for its effectiveness in reducing recurrent VTE. The study found that adjusting the length of anticoagulation treatment according to ultrasound results has been shown to decrease the incidence of recurring VTE with proximal lower DVT. This research was described by Paolo Prandoni and colleagues in 2009.[13]

Mary Barrosse-Antle and her team found that POCUS for DVT in the lower extremities offer a quick, bedside diagnostic solution. This method ensures prompt information delivery and helps avoid treatment delays.[11]

The widespread adoption of ultrasound technology has significantly decreased the use of venography for DVT diagnosis. Venography, a more invasive technique with risks from iodinated contrast reactions, was previously the standard. The introduction of POCUS for DVT diagnosis, following appropriate training for clinicians, has led to a decrease in venography usage. This shift is beneficial, reducing invasive procedures and related complications. Dimitrios Varrias' 2021 study confirmed the effectiveness of POCUS in diagnosing DVT, showing accuracy comparable to duplex ultrasonography performed in radiology departments, albeit dependent on thorough training and experience.[5]

A team led by Rabih Chaer reported that the implementation of DVT POCUS resulted in a decrease in the number of overall off-hours tests and an increase in the rate of positive studies. No adverse events were observed with the delay in testing.[17]

Clive Kearon's review concentrates on identifying initial and recurrent cases of DVT and PE. For DVT, venous ultrasound is the primary diagnostic tool being non-invasive, cost-effective, and safe, as it does not involve the use of contrast agents or ionizing radiation, while CT pulmonary angiography (CTPA) is utilized for PE. In cases where the first tests are not definitive, repeated

ultrasound exams may be conducted. While venous ultrasound effectively diagnoses initial proximal DVT, a negative test doesn't completely rule out all forms of DVT. It's important to keep monitoring patients whose VTE has been excluded for any further complications.[18]

Compression ultrasound, even when used by physicians who are not experts in vascular ultrasound, can be a dependable method for diagnosing DVT. However, findings suggest that the sensitivity of this technique when used by general practitioners may be less than ideal.[18]

A research group led by Laurence Needleman report that ultrasound is the standard imaging test for patients suspected of having lower extremity DVT. A panel of experts developed consensus that recommends a duplex ultrasound protocol with Doppler at selected sites. Although, for patients who need a venous ultrasound examination but timely ultrasound is not available, serial extended CUS is recommended.[12]

The POCUS usage by general practitioners (GPs) in primary care is on the rise. A study found that patients generally had positive feedback regarding POCUS in general practice, feeling informed about its purpose and results.

Most GPs also reported a boost in confidence regarding their diagnoses after employing POCUS. Overall, patients perceived POCUS as a seamlessly integrated part of their consultation, finding reassurance in the process. This was uncovered by Camilla Andersen and her team at Region Zealand in 2021.[19]

Keila Carrera's research team highlighted the advantages and obstacles of implementing POCUS in primary healthcare across the United States. They observed that POCUS in primary care settings can lower expenses and enhance care quality. Proper training for medical students, residents, and practicing physicians is crucial to fully leverage POCUS's benefits. Integrating it into primary care is key for patient safety and quality care. Yet, challenges exist, including inadequate training, the high cost of ultrasound equipment, and the necessity for dedicated time for both performing and interpreting images. Further collaborative efforts are required for the effective incorporation of POCUS in primary healthcare practices. Additionally, integrating ultrasound into surgical procedures has led to a notable reduction in surgical cancellations or delays, as surgeons can avoid postponing urgent operations for the sake of obtaining imaging.[19]

Vincent Cascio and his team highlighted that the global rise in obesity rates is leading to more frequent imaging challenges due to body size and those with severe edema especially by non-radiologists. As obesity is linked to a higher likelihood of thromboembolic diseases, effective imaging becomes crucial.[20]

A research group headed by François Javaudin in 2020 indicated that venous limited compression ultrasonography (VLCU) is suggested for assessing suspected DVT. They conducted a brief training for residents who had no prior experience with ultrasound. VLCU is endorsed by several organizations due to its benefits in terms of both accessibility and diagnostic accuracy.[21]

Rachel Leavitt and her team conducted a study involving 32 first-year medical students with no prior ultrasound training in abdominal scanning. They found that a tablet-based training module was effective in teaching these novice sonographers the components of the FAST exam. The participants demonstrated correct technique in 82% of the scanning tasks, indicating that this digital training module could be a valuable educational resource, especially in areas lacking formal training opportunities.[22]

Gaining proficiency in DVT ultrasound does not necessitate lengthy training. Clinicians from diverse fields were able to correctly identify or rule out femoral DVT after only three hours of theoretical and practical training.[21]

Kylie Kumar emphasized the complexity of sonography as a clinical skill, necessitating comprehensive knowledge in anatomy, physiology, and pathology, yet points out the existing gaps in understanding the perspectives of both educators and trainees within the clinical environment. They stressed the value of utilizing real patients in clinical skill teaching to add authenticity and complexity to the learning process.[23]

In a prospective comparison, Stephen A. Shiver, Matthew Lyon and colleagues found that novice emergency physician-performed ultrasound aligns well with CT venography results for diagnosing femoropopliteal DVT. However, they noted a limitation in their ability to evaluate more proximal clots (in the external iliac vein), potentially leading to false negatives in some cases.[24]

Robert C., conducted a systematic review on incorporating ultrasound training into junior medical practitioner programs. They examined 15 studies, mainly from the United States and focused on emergency medicine trainees, highlighting the feasibility of integrating ultrasound, including POCUS, into training. However, the study also points out a limitation of ultrasonography: it is less effective in detecting thrombi in the calf, pelvic, and abdominal regions.[24]

In their 2011 study, J. Bertoglio explored the use of US for DVT diagnosis in emergency departments. They found that despite its advantages, US is not used in over a third of DVT cases. The study highlights that US is both minimally invasive and highly accurate for DVT evaluation. Emergency physicians, when trained in ultrasound, can efficiently perform scans and interpret the results.[25]

CONCLUSION

Short, focused educational module is adequate to enhance the proficiency of anesthesia trainees in using ultrasound for the detection of femoral deep vein thrombosis through the compression method, leading to high accuracy and comparative performance.

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