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Research paper

Correlation between CUS and DUS for DVT diagnosis in lower extremities in the emergency department

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ABSTRACT

Background: Deep venous thrombosis (DVT) is one of the most serious thrombotic events and one of the most common cardiovascular causes associated with death due to pulmonary embolism in the emergency department.

Objectives: This study aimed to determine the correlation between two-point compression ultrasonography ($CUS_{two\text{-}point}$) and doppler ultrasound (DUS) in the diagnosis of DVT of the lower extremities.

Methods: This descriptive–analytical cross-sectional study was conducted on all patients with suspected DVT referred to two emergency departments over 6 months. Initially, all patients underwent $CUS_{two\text{-}point}$ using a linear probe on the common femoral and popliteal veins, which was performed by an emergency medicine specialist. Then DUS was performed on all patients by radiologists who were unaware of the results of $CUS_{two\text{-}point}$. The results obtained from the two procedures were recorded in a data collection form by a third-year emergency medicine assistant. The data was analyzed by SPSS 23 software.

Results: Overall, 129 patients were enrolled, the mean age of whom was 56.18 ± 16.33.68 years. There were 68 males (52.7%) and 61 females (47.3%) among the participants. The positivity or negativity of the data retrieved from $CUS_{two\text{-}point}$ and DUS was assessed by the McNemar test, and a *P*-value of 1 indicated the homogeneity of both tests. Compared to DUS (as the gold standard), the sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of the $CUS_{two\text{-}point}$ method were obtained as 97.56%, 95.74%, 97.56%, 95.74%, and 96.9%, respectively. The accuracy of 96.9% of $CUS_{two\text{-}point}$ along with Cohen's kappa of 0.93 indicated a high agreement between the two ultrasound methods.

Conclusion: CUS seems to be a non-invasive, safe, and accessible method in the emergency department that can provide an appropriate alternative to DUS for the diagnosis of DVT in the lower extremities.

Keywords: deep venous thrombosis, emergency department, pulmonary embolism, ultrasound

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INTRODUCTION

Deep venous thrombosis (DVT) is one of the most serious problems and one of the most common cardiovascular causes associated with death due to pulmonary embolism (PE).[1,2] The annual mortality rate of DVT and PE in the United States is about 300,000–600,000 people. This rate in Iran is about 130 to 395 cases per 1000 patients. Therefore, the timely diagnosis of this condition in the emergency department is highly important.[3]

DVT is often asymptomatic, which is possibly due to the lack of complete occlusion of veins or their lateral branches, rendering clinical history and physical examination (i.e., Wells' criteria) unreliable for DVT diagnosis.[4] Doppler ultrasound is known as a non-invasive, rapid, dynamic, and radiation-free diagnostic method for DVT. However, this procedure has some limitations such as low applicability for very deep vessels and obese patients (BMI above 35), as well as operator dependence outcomes. Nevertheless, the procedure benefits from high reliability and clinical acceptance and delivers results strictly consistent with that of the gold standard method. The use of two-point compression ultrasonography ($CUS_{two\text{-}point}$) on the common femoral and popliteal veins is increasing in the emergency department. The level of agreement between doppler ultrasound (DUS) and $CUS_{two\text{-}point}$ is among the issues studied by researchers.[5–7]

OBJECTIVES

This study aimed to determine the correlation between $CUS_{two\text{-}point}$ and DUS in the diagnosis of DVT of the lower extremities.

MATERIALS AND METHODS

Study Design

This was a descriptive–analytical cross-sectional study. The statistical population of this study included all patients with suspected DVT referred to the emergency departments of Afzalipour Academic Hospital and Shahid Bahonar Academic Hospital of Kerman, the largest referral medical center located in southeastern Iran. Inclusion criteria were DVT suspicion based on Wells' criteria, clinical suspicion of DVT based on the discretion of at least one emergency medicine specialist, and willingness to participate in the study. Exclusion criteria encompassed a history of vascular surgery or chronic vascular insufficiency, implantation of a femoral catheter, and reluctance to participate.

Patients Sample

Data collection was conducted over 6 months from March 1st, 2021 to September 1st, 2021. After obtaining ethical approval and making necessary arrangements with the officials of Shahid Bahonar and Afzalipour hospitals, the objectives and design of the study were explained to patients or their companions, and their questions were answered before asking them to sign an informed consent form. Out of 140 patients admitted during the mentioned period, 129 were finally included in the study, 4, 1, and 6 of whom were excluded due to a history of chronic vascular problems, carrying a femoral catheter, and reluctance to participate, respectively.

Measurements

All patients with suspected DVT underwent $CUS_{two\text{-}point}$ on the common femoral and popliteal veins.[8,9] Although it was possible to conduct $CUS_{three\text{-}point}$ as well, regarding the comparable sensitivity and specificity of $CUS_{two\text{-}point}$ and the recommendations for performing $CUS_{two\text{-}point}$ in the emergency department, this procedure was chosen.[10] All ultrasounds were performed by the same emergency medicine specialist using a 7.5 MHz linear probe by a portable big device (DC-7 Mindray Ultrasound Machine, China). Although the physician was not blinded to the study, he was unaware of the results obtained by DUS, which was performed by a radiologist after transferring patients to the radiology department. The radiologists who performed DUS were unaware of the results of the $CUS_{two\text{-}point.}$ DUS was conducted using Medison Accuvix (South Korea). A third-year emergency medicine assistant recorded the results of the two procedures in a data collection form.

Statistical Analysis

Qualitative parameters were presented by frequency percentage, and quantitative variables were described by mean and standard deviation. Cohen's kappa coefficient was used to determine the agreement between the findings of the two methods. A *P*-value of <0.05 was considered statistically significant. SPSS 23 software (SPSS Inc., Chicago, IL, USA) was used for data analysis.

RESULTS

Overall, 129 patients enrolled in the study, the mean age of whom was 56.18 ± 16.33 years. There were 68 males (52.7%) and 61 females (47.3%) among the participants. The results of Wells' criteria scoring and the comparison of DVT locations as detected by $CUS_{two\text{-}point}$ and DUS are presented in Tables 1 and 2, respectively. The McNemar test was used to compare the positive and negative rates of $CUS_{two\text{-}point}$ and DUS, where a *P*-value of 1 indicated the homogeneity of the two methods (Table 3). Finally, the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), accuracy, and Cohen's kappa of $CUS_{two\text{-}point}$ were determined according to DUS as the gold standard (Table 4), rendering the values of 97.56%, 95.74%, 97.56%, 95.74%, and 96.9%, respectively. Accordingly, the accuracy of 96.9% of $CUS_{two\text{-}point}$ and Cohen's kappa of 0.93 reflected a high agreement between these two ultrasound methods.

Table 1. Wells' score for DVT.

Wells' score	*N* (%)
<1 (low probability)	11 (8.53)
1–2 (moderate probability)	67 (51.94)
>2 (high probability)	51 (39.53)

Abbreviation: DVT: deep vein thrombosis.

Table 2. Comparison of DVT sites between $CUS_{two\text{-}point}$ and DUS.

Site	$CUS_{two\text{-}point}$	DUS
Common femoral vein, *n* (%)	6 (4.7)	1 (0.8)
Popliteal vein, *n* (%)	4 (3.1)	3 (2.3)
Both, *n* (%)	72 (55.7)	78 (60.5)

Abbreviations: DVT: deep vein thrombosis; $CUS_{two\text{-}point}$: compression ultrasonography at two-point (common femoral and popliteal vein); DUS: doppler ultrasound.

Table 3. Comparison between positivity and negativity of the $CUS_{two\text{-}point}$ and DUS.

			DUS			
			+	–	Total	*P*-value
$CUS_{two\text{-}point}$	+	Count	80	2	82	1
		% of Total	62	1.6	63.6	
	–	Count	2	45	47	
		% of Total	1.6	34.9	36.4	
Total		Count	82	47	129	
		% of Total	63.6	36.4	100	

Abbreviations: $CUS_{two\text{-}point}$: compression ultrasonography at two-point; DUS: doppler ultrasound.

Table 4. Sensitivity, specificity, PPV, NPV, accuracy, and Cohen's kappa of the $CUS_{two\text{-}point}$.

Parameter	Estimate	95% CIs
Sensitivity	97.56%	(91.54, 99.33)
Specificity	95.74%	(85.75, 98.83)
PPV	97.56%	(91.54, 99.33)
NPV	95.74%	(85.75, 98.83)
Accuracy	96.9%	(92.30, 98.79)
Cohen's kappa	0.9331	(0.7605–1.100)

Abbreviations: PPV: positive predictive value; NPV: negative predictive value; $CUS_{two\text{-}point}$: compression ultrasonography at two-point; CI: confidence interval.

DISCUSSION

Our results showed that $CUS_{two\text{-}point}$ can be an appropriate alternative to DUS for DVT diagnosis in lower extremities in the emergency department, offering high diagnostic accuracy in this regard.

One of the diagnostic methods for DVT is CUS, which is recommended to be used in the emergency department as a safe, accessible, and non-invasiveness technique. All emergency specialists can master this non-invasive procedure after participating in a training course. This diagnostic procedure can be performed in less than four minutes.[11] In a study, Hannula et al. described that CUS training for general practitioners was highly effective in boosting their skills and knowledge. In their retrospective study, they declared that this training course would result in a noticeable reduction in the number of patients referred to the hospital with suspected DVT, offering a zero diagnostic error rate[12] and a considerable cut in costs.[13] Considering these benefits, this technique is recommended to be employed as a DVT diagnostic modality in the emergency department.[14]

Studies have been conducted to verify the accuracy of CUS for DVT diagnosis. Dehbozorgi et al., in a prospective study with 240 patients, compared the accuracy of CUS and DUS for DVT diagnosis in lower extremities, reporting the sensitivity, specificity, and accuracy of CUS as 100%, 93.3%, and 96.4%, while the corresponding values for DUS were 100%, 92.1%, and 96.2%, respectively.[15]

In another study, Mumoli et al. enrolled 1107 participants to determine the diagnostic accuracy of CUS for DVT and reported the sensitivity, specificity, and accuracy of 90%, 97.1%, and 95.8%, respectively.[16]

Canakci et al. studied 226 patients to investigate the efficiency of CUS for DVT diagnosis and reported that the sensitivity, specificity, PPV, and NPV of this method were 93%, 93%, 83%, and 97%, respectively. Considering the high diagnostic sensitivity and specificity of this technique, these researchers advised the use of this method as a primary screening tool for DVT diagnosis in the emergency department.[17]

Fischer et al., in a study with 73 patients, evaluated the diagnostic performance of CUS for DVT and reported the sensitivity, specificity, PPV, and NPV of 100%, 95.8%, 61.5%, and 100%, respectively.[18] In another study by Crisp et al., 47 patients with suspected DVT underwent CUS, delivering sensitivity and specificity of 100% and 99%, respectively. Accordingly, Crisp et al. recommended the use of this non-invasive procedure in the emergency department to detect DVT.[19]

In our study, CUS was performed on 129 patients with suspected lower extremity DVT, rendering the sensitivity, specificity, PPV, negative aberration value, and accuracy of 97.5%, 95.7%, 97.5%, 95.7%, and 96.9%, respectively. According to Cohen's kappa coefficient obtained (0.933), as a measure for investigating the degree of agreement between two methods,[20] the agreement between $CUS_{two\text{-}point}$ and DUS for DVT diagnosis in suspected patients was perfect, suggesting that CUS can be an efficient method to detect DVT in the emergency department. In a similar study with 138 patients with suspected DVT in lower limbs, conducted by Elsenga et al., the agreement between the diagnoses made by emergency physicians and radiologists according to Cohen's kappa was 0.87. A recent study showed that emergency physicians and even medical emergency assistants could offer a diagnostic accuracy comparable with that of radiologists for lower limb DVT.[21]

LIMITATIONS

Among the limitations of this study are the ultrasounds being conducted by a non-blinded emergency medicine specialist, the lack of recording of the duration of the procedure, and some patients' refusal to participate in the study.

CONCLUSION

$CUS_{two\text{-}point}$ offers a non-invasive, safe, and accessible method that can be used as a viable alternative to DUS to detect lower limb DVT in the emergency department.

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CONFLICT OF INTEREST

No potential conflict of interest was reported by the authors.

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ETHICAL APPROVAL

The study was approved by the Ethics Committee of Kerman University of Medical Sciences [IR.KMU.AH.REC.1400.148.].

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