Original Article

Comparison of diagnostic value of conventional ultrasonography by emergency physicians with doppler ultrasonography by radiology physicians for diagnosis of deep vein thrombosis

Saeed Abbasi,[1] Ehsan Bolverdi,[2] Mohammad Amin Zare,[3] Peyman Hafezimoghadam,[4] Marzieh Fathi,[5] Davood Farsi,[6] Mehrdad Moghimi[7]

Department of Emergency Medicine, Tehran University of Medical Sciences,[1,3-6] Department of Emergency Medicine, Mashhad University of Medical Sciences,[2] Department of Surgery, Shaheed Beheshti University of Medical Sciences,[7] Tehran, Iran.

Corresponding Author: Davood Farsi. Email: davoodfa2004@yahoo.com

Abstract

Objectives: To determine sensitivity, specificity and other operating characteristics of bedside three-point compression ultrasonography performed in emergency department by emergency physicians in comparison with duplex ultrasonography.

Methods: The cross-sectional study at Rasoul-e-Akram Hospital in Tehran, Iran, prospectively evaluated 81 suspected patients of lower extremity deep vein thrombosis between March 2006 and March 2007. A trained second-year resident and one attending physician of emergency medicine evaluated the veins of all the patients with through compression ultrasonography. Then, a second-year resident of radiology assessed the patients with duplex ultrasonography. Finally, data were compared and quantitative and categorical variables were worked out along with other statistical analysis through SPSS version 16.

Results: The mean age of the patients was 47.2±18.6 years. When cases who lost the compressibility of at least one of their femoral or popliteal veins were considered to be positive, there were 80.2% diagnosed by compression ultrasonography and 79% by the duplex variety. Sensitivity, specificity and accuracy of the former in comparison with the latter were 85.9%, 41.2% and 84.6% respectively.

Conclusion: Compression ultrasonography has relatively an acceptable sensitivity and accuracy level, but has low specificity in the diagnosis of deep vein thrombosis in the hands of Iranian emergency physicians. It is better to implement duplex ultrasonography whenever accessible. Otherwise, compression ultrasonography results should be compared with the results of duplex ultrasonography as soon as possible.

Keywords: Venous thrombosis, Doppler ultrasonography, Ultrasonography; Emergency medicine (JPMA 62: 461; 2012).

Introduction

Timely diagnosis and treatment of patients with deep vein thrombosis (DVT) significantly decreases pulmonary emboli and its haemodynamic complications. On the other hand, incorrect diagnosis of patients without DVT causes unessential anti-thrombotic medications and their complications.[1,2]

Medical history and physical examination are not enough to diagnose DVT due to low validity of clinical signs and symptoms.[3] Therefore, we need a rapid test with sufficient accuracy to diagnose the condition. Venography is the only test which can confirm or rule out DVT. Venography is the gold standard for diagnosis of DVT which is invasive and needs contrast agents.[4] However, it cannot be performed or is technically incomplete or un-interpretable in 20-25% of cases.[3] Duplex ultrasonography (DUS) is a good alternative for venography, but needs an expert radiologist who is not accessible round the clock in most emergency departments (EDs).[5]

Nowadays, D-dimer and clinical evaluation (like Wells' criteria) have a widespread usage for the diagnosis of DVT, which also are not accessible in all laboratories or take hours to be ready.[6] This will increase the risk of complications like pulmonary emboli, decrease the satisfaction of the patients and increase crowdedness in the ED.

Venography and DUS need to transfer the patients to the radiology department which increases time, risk and cost for both patients and the health system. So, simpler and cheaper methods for on-time diagnosis in ED are preferred.

Previous studies have shown that 99% of patients suspected for DVT have femoral and popliteal vein involvement. Thus, ultrasonography can be limited to these veins.[7]

The increasing number of referral patients with suspected DVT, in accessibility of DUS in EDs, complications of anti-coagulant agents in suspected patients with coagulopathy, and the absence of the accurate, accessible, quick, user-friendly and cost-effective method made us to evaluate the diagnostic value of such a method in our region.[8,9] The current study, as such, assessed the accuracy of conventional (compression) ultrasonography (CUS) in comparison with DUS which is the test of choice for the diagnosis of DVT and an acceptable alternative for venography in such research studies.

Patients and Methods

In this analytical cross-sectional study, we prospectively evaluated 81 adult consecutive suspicious patients suspected of having lower extremity DVT who were referred to the ED of Rasoul-e-Akram Hospital, Tehran, Iran, between March 2006 and March 2007. The evaluation was based on patients' history and physical examination.

Considering the probability of obtaining a positive test, its confidence interval, estimated sensitivity, and specificity of the test equal to .25, .2, .97 and .97, respectively, and using a formula when a perfect gold standard test is not available,[10] the sample size was estimated at 81.

All the 81 patients were suspected of DVT based on history (cramp, pain or swelling in lower extremities beginning in the preceding 7 days) or physical examination (swelling, asymmetry in lower extremities size, colour changes or calf tenderness). Patients who refused to participate in the study and those with a history of trauma to the affected extremity, history of vascular surgery in the same extremity, presence of indwelling femoral catheters, ultrasound studies before having been referred to our ED, history of chronic DVT or haemodynamically unstable patients were excluded from the study.

A postgraduate second year (PGY-2) trained resident supervised by an emergency medicine (EM) attending physician, who was expert in performing CUS for diagnosing suspected DVT, evaluated the femoral or popliteal veins of all patients with a CUS device (Honda HS-2000, Toyohashi Aichi, Japan) after probable diagnosis of DVT. Then, a PGY-2 resident of radiology assessed the patients with DUS (Mylab 70, Biosound ESAOTE, USA) for confirming the diagnosis. Radiologists were blinded to the results of the ED ultrasonography. The radiologists' report of duplex study was considered the 'gold standard.'

An ultrasound study was considered normal if the vein was completely compressed, and abnormal if the vein was incompressible or an occlusive clot was detected in target areas, including common femoral vein at the level of inguinal crease, superficial femoral vein superior to the adductor canal and popliteal vein in popliteal fossa. Compressibility of veins was evaluated in the transverse view. The vein was considered 'non-compressible' (indicating the presence of DVT) if the vein remained open while the adjacent artery was obliterated by applying pressure. The results were reported as positive for DVT (non-compressible or not visualised veins in one or more target points) and negative for DVT (compressible veins in all three target points).

We compared the results of CUS by ED resident with the results of DUS of the radiology resident.

A checklist was completed for the patients at the time of admission, addressing demographic variables (age, gender, educational level, job, marital status, and income), history of DVT, risk factors (obesity, physical inactivity, dyslipidaemia, smoking, and familial history), height, and weight.

Data were collected through medical history and physical examination. Checklists were filled out by trained residents of emergency and radiology.

We used mean±SD (standard deviation), and 95% confidence interval (CI) for description of quantitative variables, t-test for the comparison of quantitative variables, and chi-square and Fisher exact test where necessary, for the comparison of categorical variables in analysis. Operating characteristics consisted of sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), positive likelihood ratio (PLR), negative likelihood ratio (NLR), and accuracy were assessed. Differences or correlations with $P < 0.05$ were considered to be statistically significant. SPSS version 16.0 (SPSS Inc. Chicago, Illinois, USA) and EPI 6 were used for analysis.

The study protocol was reviewed and approved by the Iran University of Medical Sciences Ethical Committee. Informed written consent was obtained from each patient who was part of the study. The study protocol conformed to the ethical guidelines of the 1975 Declaration of Helsinki.

Results

The mean age of the patients was 47.2±18.6

Table-1: Sensitivity, specificity, positive and negative predictive values and positive and negative likelihood ratios of the compression ultrasonography in comparison with Doppler ultrasonography.

	Sensitivity	Specificity	PPV	NPV	PLR	NLR	Accuracy
In all cases							
Femoral	76.3 (63.1-86)	40.9 (21.5-63.3)	77.6 (64.4-87.1)	39.1 (20.5-61.2)	1.3 (.8-2.3)	.6 (.2-1.7)	66.7
Popliteal	54 (39.5-67.9)	58.1 (39.3-74.9)	67.5 (50.8-80.9)	43.9 (28.8-60.1)	1.3 (.7-2.7)	.8 (.4-1.5)	55.5
Total	85.9 (74.5-93)	41.2 (19.4-66.5)	84.6 (73.1-92)	43.8 (20.8-69.4)	1.5 (.9-2.8)	.3 (.1-1.3)	76.5
In Females							
Femoral	95.2 (74.1-99.8)	28.6 (9.6-58)	66.7 (47.1-82.1)	80 (29.9-98.9)	1.3 (.8-2.4)	.2 (.003-2.7)	68.6
Popliteal	47.4 (25.2-70.5)	43.8 (20.8-69.4)	50 (26.8-73.2)	41.2 (19.4-66.5)	.8 (.3-2.3)	1.2 (.4-3.6)	45.7
Total	96 (77.7-99.8)	30 (8.1-64.6)	77.4 (58.5-89.7)	75 (21.9-98.7)	1.4 (.8-2.8)	.1 (.003-2.8)	77.1
In Males							
Femoral	65.8 (48.6-79.9)	62.5 (25.9-89.8)	89.3 (70.6-97.2)	27.8 (10.7-53.6)	1.8 (.7-7.8)	.5 (.2-2)	65.2
Popliteal	58.1 (39.3-74.9)	73.3 (44.8-91.1)	81.8 (59-94)	45.8 (26.2-66.8)	2.2 (.7-8.4)	.6 (.3-1.4)	63
Total	79.5 (63.1-90.1)	57.1 (20.2-88.2)	91.2 (75.2-97.7)	33.3 (11.3-64.6)	1.9 (.8-7.6)	.4 (.1-1.8)	76

PPV: Positive predictive value, NPV: Negative predictive value, PLR: Positive likelihood ratio, NLR: Negative likelihood ratio.

Table-2: Diagnostic value for DVT in some studies.

Author/Year/ref	Sample size/Region	Gold Standard	Accuracy/Sen/Spc (%)
Krings W/1990/[23]	235/Germany	Phlebography	?/93-100/96-99
Aywak AA/2007/[24]	44//Kenya	Venography	90.9/88.9/91.8
Crisp JG/2007/[25]	199/USA	Doppler ultrasound	?/ 100/99.1
Kline JA/2008/[26]	183//USA	Venous ultrasonography	85/70/89

?: not determined in study.

years. There were 46 (56.8%) male and 35 (43.2%) females.

CUS and DUS of the femoral vein in the suspected patients were positive in 58 (71.6%) and 59 (72.8%), respectively. These indices were 40 (49.4%) and 50 (61.7%) in the evaluation of the popliteal vein, respectively. When cases who lost the compressibility of at least one of their femoral or popliteal veins considered to be positive cases, there were 65 (80.2%) diagnosed by CUS and 64 (79%) by DUS. There were 10 (12.3%) and 9 (11.1%) cases with false positive and false negative results, respectively.

Sensitivity, specificity and accuracy of CUS in comparison with DUS were 85.9%, 41.2% and 84.6% in these cases, respectively (Table-1). Sensitivity, PLR and accuracy were higher in the diagnosis of deep femoral vein thrombosis; while specificity, NPV and NLR were higher in the diagnosis of popliteal vein thrombosis. However, none of these differences were statistically significant. Regarding gender difference, male and female did not have statistically significant difference in any parameter. Considering thrombosis in each vein (deep femoral or popliteal) and both genders (male and female), the best indices were sensitivity, PPV and accuracy. In females, sensitivity, PPV, NPV and accuracy were acceptable. In males, sensitivity, PPV and accuracy were in the higher range as well.

Discussion

Portable ultrasonography devices used by ED residents are small, do not have high cost, can be used by relatively small hours of education, decrease the time of diagnosis, do not need many personnel and equipment, and can be life-saving. Sometimes, it is not possible to send a suspected patient of DVT to the radiology department due to instability in vital signs and haemodynamic condition. But does this method have sufficient accuracy in our region?

Considering thrombosis in each one of the femoral or popliteal veins, regardless of the gender, the accuracy of CUS was 76.5%. This ratio was higher in femoral compared to the popliteal vein. It is not an acceptable percentage and we cannot rely solely on this method as a single test due to both false negative (11.1%) and false positive (12.3%) results. We should consider either more accurate tests like DUS for the diagnosis of DVT or find a competing method which can be used with CUS to increase its accuracy, specifically when the results are negative.

However, the accuracy of each test depends on device, experience and knowledge of the physician, and time of implementing DUS (day, night, and midnight). Maybe low hours of training and doing CUS by PGY-2 residents can be the causes for such low accuracy.

One study on 156 patients pointed that the time of

triage to diagnosis significantly decreases from 220 to 95 minutes when the procedure is done by the radiology department in comparison with the ED in the presence of an active 24-hour radiology ward which usually does not exist.[11] There were also a high agreement between the diagnosis made by the ED and radiology department (Kappa=0.9) in that study. So, the benefit of saving the time is clear.

However, one study has expressed that experience of residents (measured as residency year) was not correlated with the diagnosis of the clot in suspect patients for DVT.[12]

Another study illustrated that PPV and NPV were 50% and 96% respectively in acutely ill patients in the ICU, but without thrombosis symptoms. So, CUS underestimates the thrombosis in veins in comparison with venography in such patients.[13]

In our study, the sensitivity of CUS was 54.0% in detecting the distal DVTs. This is compatible with results of a meta-analysis by Goodacre et al, which showed a 56.8% sensitivity for ultrasound performed by radiologists in detecting the distal DVT.[14] Another meta-analysis by Kearon et al reported a sensitivity of 50% to 75% in distal DVTs (diagnosis by compression ultrasound).[15] Distal DVTs which are defined as the thrombosis in infra-popliteal veins (calf DVTs) make only 20% of all lower extremities' DVTs and have a much lower tendency to embolise, according to some studies.[16] Uncertainty in clinical significance of these DVTs makes the achieved sensitivities acceptable.[17,18]

We found 76.3% sensitivity for bedside ED CUS in detecting the proximal DVTs. This is lower than the findings of Kearon et al[15] who found 97% sensitivity and the meta-analysis by Goodacre et al[14] who found a pooled sensitivity of 93.8% in detecting the proximal DVTs by CUS performed by radiologists. We also found a lower specificity than the studies of Kearon[15] and Goodacre;[14] 41.2% compared with 98% and 97.8%.

A systematic review published in 2008 showed overall sensitivity of 0.95 (range: 0.89-1.00) and specificity of 0.96 (range: 0.76-0.99) for emergency physician-performed ultrasonography (EPPU) in comparison with radiology-performed (as a standard criterion) imaging for the diagnosis of DVT.[19] This study neither evaluated foreign-language evidences nor considered publication bias. It seems that their results are inflated. Few studies in this systematic review have compared CUS with DUS.

Comparison with other countries that was not included in this systematic review are also available (Table-2) and demonstrate sensitivity and specificity ranges between 70% and 100% in different areas around the world.

DUS has a sensitivity and specificity of 76.1% and 100%, respectively in comparison with venography (which is the gold standard for the diagnosis of DVT).[20] We recommend DUS as an alternative safe, cheap, accessible and valid method for venography that is usually not done. This will prevent much referrals to radiologists, and the alternative is specifically sufficient for centres that do not have a 24-hour radiologist.

In a USA study, of 121 symptomatic extremities, vascular technicians detected nine cases of acute DVT (aDVT) in the target area (7% prevalence; 95% CI 3%-12%); resident examinations revealed eight of these (sensitivity 89%, 95% CI 55%-100%).[12]

Of the 112 patients ultimately determined as not having aDVT in the pre-defined target area, the resident evaluation was concordant in 109 cases, with three false positives (specificity 97%; 95% CI 95%-100%).[12] This study believes that EM residents can perform a limited duplex examination with considerable but not perfect accuracy after receiving very limited instructions.[12]

Although some studies have proposed that negative predictive value of emergency physician performed compression ultrasound study is enough to eliminate the necessity of repeat ultrasound during the next week,[21] we found a negative predictive value of 43.8% which mandated the need for more comprehensive studies to determine the presence or otherwise of DVT.

Some evidences suggest that physicians should not send patients with either definite diagnosis such as pain and swelling of the lower limb with simultaneous proven pulmonary emboli or cases with very low probability of DVT according to medical history and physical examination to the radiology department.[20]

Like our study, Stein et al also believed that males and females do not have a statistically significant difference in the diagnosis of DVT according to routine existing diagnostic methods.[22]

Despite most other studies, the accuracy of CUS in our study was not high in comparison with the DUS. We should consider that most other studies have compared CUS with venography or other methods as the gold standard. Unfortunately, as we discussed above, there are few papers similar to the present study which has compared diagnostic accuracy of DUS with CUS for the diagnosis of DVT.

Since we had some sonographic reports with negative results in clinically suspect patients by emergency residents, it can be concluded that the imagination of our physicians does not affect the

exposition of the sonographic results.

In terms of limitations, the study had a relatively low sample size, and did not compare-like data with venography which is the gold standard for DVT diagnosis.

Conclusion

CUS has a relatively acceptable sensitivity and accuracy, but low specificity in the diagnosis of DVT in Iranian patients. It cannot be a good alternative for the more accurate selective methods which are routinely used at present. It is better to implement DUS whenever accessible. Otherwise, CUS can be used as an alternative, but it results should be compared with those of DUS as soon as possible.

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