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Comparison of the Precision of Compression Ultrasonography and Duplex Sonography in Deep Venous Thrombosis Patients

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Abstract

Deep venous thrombosis is a prevalent disease and difficult being detected which can be lethal if developed. Ultrasonography and duplex ultrasonography are two of the diagnostic methods with their restrictions. The present study addresses the analysis of the succession of compression ultrasonography as a method with less restrictions in comparison with ultrasonography and duplex ultrasonography. The present study was conducted in the central urgency section of Imam Reza Hospital, Mashhad, Iran, which is a public academic institute, on 70 patients in 2014. All patients were subjected to compression ultrasonography before duplex ultrasonography and those who had previous duplex ultrasonography sessions with available results were excluded from the investigations. Finally, the results of 63 patients were analyzed, 7 being excluded due to their inaccessible data. According to the results, 52 percent of subjects were males and 48 percent were females. The result of the regular ultrasonography was positive for 37 and negative for 26 patients. Duplex ultrasonography, however, led to positive results for 35 patients (equivalent to 37 lower limb organs) and negative results for 28 subjects (equivalent to 41 lower limb organs). The sensitivity, specificity, and precision of the diagnosis via compression ultrasonography were found to be 97, 90, and 93.5 percent, respectively, and the positive and negative predictive values were calculated to be 90 and 97 percent, respectively, with a CI of 95 percent. The diagnostic accuracy of 96.8% suggests that the use of compression sonography can be a good accuracy in the diagnosis of deep vein thrombosis of the lower extremities, but it cannot replace more accurate methods that are currently used as available selected diagnostic methods.

Keywords: ultrasonography, chromatography, veins, thrombosis

1. Introduction

Deep vein thrombosis (DVT) is a common problem whose diagnosis is often difficult and when it is in progress can be fatal. However, early treatment improves the prognosis. Thus, both in symptomatic patients with accurate differential diagnosis and at risk asymptomatic patients, necessary care must be taken (Kahn & Ginsberg, 2002). There are many tools for evaluation DVT. Currently, conventional sonography (compression sonography) is the most effective diagnostic tool in the emergency department that has shown the greatest accuracy and lowest cost. However, the ability of sonography technician may delay sonography or not be taken for low-risk patients (Fox & Bertoglio, 2011).

Failure to timely diagnosis and treatment of (DVT) patients exposes them to a significant risk of pulmonary embolism and hemodynamic risks. The later the (DVT) is diagnosed, the risk of pulmonary embolism and other postphlebitic syndromes increases. On the other hand, misdiagnosis of this disease puts the patients at risk of receiving unnecessary anticoagulants and their complications (Fox & Bertoglio, 2011; Kahn & Ginsberg, 2002). According to the studies carried out, history and physical examination of the patient cannot be sufficient in diagnosing (DVT), because they do not have the necessary sensitivity (Frazee & Snoey, 1999; McRae & Ginsberg, 2004).

Thus, a test is needed that has high precision in detecting (DVT) and at the same time, the characteristics of a rapid test suitable for use in the emergency department, because in surgery, “time” in detection (DVT) is crucial. Now, in many parts of the emergency, measuring a protein called D- dimer is used as an appropriate testing to diagnose

patients with suspected (DVT). However, this test can rule out less than 50% of patients with suspected (DVT), yet it's being positive does not prove (DVT) (Gaitini, Beck-Razi, Haim, & Brenner, 2006; Michiels et al., 2005; Thalhammer & Aschwanden, 2006).

Sonography as the golden standard now is less used for DVT diagnosis, and it has more surgical applications (van der Graaf et al., 2000). Intravenous sonography needs the patient to be transferred to the radiology department, and must be done by a radiologist (Chung, Luk, Lo, & Lo, 2015; Goldhaber & Bounameaux, 2012; Ohmori et al., 2015). Thus, it incurs more time and cost to the patient and on the other hand, due to social and economic situations, residing a radiologist for 24 hours in the hospitals is impossible, and the shortage of skilled manpower is seen more in less developed areas and in remote cities. Therefore, several studies have been carried out for discovering low-cost and easier methods for early detection that can be used in the emergency department, too.

Most studies (99%) have shown that the majority of symptomatic patients with suspected (DVT) have femoral and popliteal veins problems. Therefore, sonography checking can be limited to these two veins (Constantini, Kornowski, Pomeranz, & Rappaport, 1991). Considering the above, and with more attention to the importance of time, at the start of treatment for patients (DVT) in order to prevent pulmonary embolism have led emergency departments in different parts of the world to have emergency physicians receive the necessary training, and use portable sonography machines for diagnosis in the emergency department. It should be noted that, the use of duplex sonography is valuable when a follow-up sonography, after the initial sonography, and in an interval of 5-7 days, is conducted. This is done because if thrombosis is created in the distal veins, at this time, it begins to move upward, so the follow-up sonography can detect it (Chung et al., 2015; Cogo, Lensing, Prandoni, Buller, et al., 1993; Kamusella et al., 2008; Lutterbach-Penna et al., 2012).

Duplex sonography is accepted as an alternative to venography, which is the golden standard test to detect deep vein thrombosis of the lower extremities. The aim of this study is to evaluate the accuracy of sonography compression, compared with duplex sonography that is the selected method for (DVT). In this study, we have tried to evaluate and calculate the sensitivity and accuracy of compression ultrasonography in the femoral and popliteal veins, separately and together.

2. Methods

This is a cross-sectional applied study that was conducted to evaluate the diagnostic accuracy of clinical tests. All the patients who referred to Imam Reza Hospital in Mashhad, with clinical symptoms and physical findings with suspected deep vein thrombosis, during the years 2013 and 2014 were included in the study. Given the half-percent prevalence of DVT, and according to previous studies done in this area (Abbasi et al., 2012; Caronia et al., 2014; Farahmand, Farnia, Shahriaran, & Khashayar, 2011; Shiver, Lyon, Blaivas, & Adhikari, 2010) estimation of the number of the patients for study during one year was 70 patients. Patients were included in the study, based on the findings from the history and physical examination on arrival at the emergency department with suspected DVT, independent of age, gender, previous history of deep vein thrombosis, and the risk factors underlying possible.

After the inclusion of patients in the study, compression sonography or conventional sonography was performed in the emergency department by two residents of fixed emergency physicians who had been trained to perform sonography. Pre-made checklists were filled out to record history, physical examination, and sonography of the patient at different hours of the day, on different days of the week and the months of the year, based on the patients' referring time.

For sonography, portable devices in the ward were used. Studied veins included femoral and popliteal veins. Positivity or negativity of the test was defined as the compressibility of the vein wall in cross-section. Initially, venous blood flow was assessed using sonography probe, and then its wall compressibility under superb pressure was reviewed. If under sonography probe pressure, the vein wall was pressed the test result was "negative," and if it was not compressed the vein had clot and the test result was "positive." The results of each of the femoral and popliteal veins were recorded separately. All patients in emergency departments were undercuts for the patient, and to carry out this, the patients were in supine position on the bed, and at first the femoral vein and then popliteal vein related to flexion 45 degrees of knee underwent ultrasonography.

After sonography compression, patients were sent to the radiology department to undergo duplex sonography. In the radiology department, patients underwent duplex sonography by resident radiologist. Patients' duplex sonography outcomes were reviewed according to the radiologist or radiology resident reports. After completing the one-year period of the study, information about the patients were extracted from the checklists filled by two emergency physicians, and using SPSS version 16 and EXCEL 2007 were described and analyzed.

To calculate the diagnostic accuracy of the test, according to Table 1, false positive, true positive, false negative

and true negative cases were investigated. Based on the Table 1, sensitivity, PPV and NPV were calculated according to the following equations.

$$\text{Sensitivity} = P/TP+FN \qquad \text{Specificity} = N/FP+TN$$

$$PPV = TP/TP+FP \qquad NPV = TN/TN+FN$$

Table 1. Sensitivity, PPV and NPV were calculated according to the mentioned equations

Compression ultrasonography	Duplex ultrasonography (Golden standard)		
	Positive	Negative	
Positive	True positive (TP)	False positive (FP)	TP + FP
Negative	False negative (FN)	True negative (TN)	FN + TN
	TP + FN	FP + TN	TP + FP + FN + TN

3. Results

During the 1-year study, 70 patients with suspected deep vein thrombosis of the lower extremities, referring to Imam Reza Hospital, Mashhad were included in the study by census method and were reviewed using compression ultrasonography by 2 residents of emergency department. All patients, in the same shift, were sent to the radiology department of the hospital to perform duplex sonography. One of the patients died before carrying out further duplex sonography investigations and in six cases the results of duplex sonography was not received by the patient. These seven patients were excluded from the study. Thus, the final study was conducted on 63 patients and a total of 78 lower limbs underwent sonography.

The results showed that the mean age of the patients was 54.71 years where the minimum age was 22 and maximum 96. The highest prevalence was observed in the age range 45-50 years (Figure 1). Gender distribution was such that 30 patients (%47.6) were female and 33 patients (% 52.4) were male.

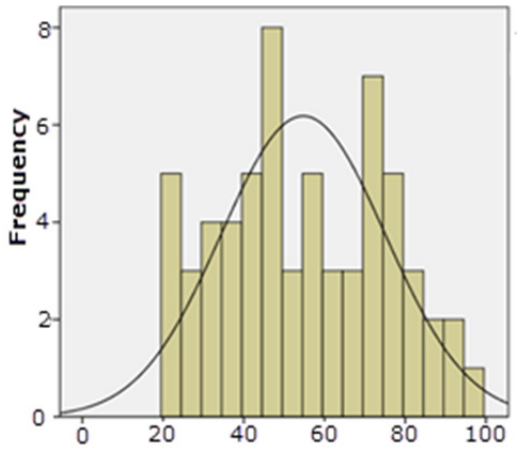

Figure 1. Frequency Chart for Age of Patients participated in this Study

Given that the application of sonography for each patient is based on clinical examination and clinical control dvt, therefore for 49 patient's duplex ultrasonography was performed in a lower extremity and opposite lower limb that physician did not have clinical suspicion and had no evidence of dvt has been considered as negative for dvt calculations. The survey showed that of the total 63 patients in the study via CUS, 37 patients suffered DVT, but the results in the radiology service with DUS were that 35 patients suffered DVT and 28 patients did not.

The results obtained in this study showed that out 78 popliteal areas of lower limb, 30 (28.8%) cases had dvt in duplex sonography where 34 cases had positive noncompressible in cus sonography. Moreover, of the total 78 femoral areas of lower limb, 28 (22.22%) cases had dvt in duplex ultrasonography that had 33 positive femoral areas noncompressable cus for sonography.

In point-by-point popliteal and femoral vein check in two sonography methods performed, in all sonography of femoral area in CUS, in 6 cases non-compliance in form of false positives was observed more than DUS thrombosis method. This was while point-by-point popliteal and femoral vein check in two sonography methods performed, in total sonography of popliteal area in CUS in four cases non-compliance in form of false positives was observed more than DUS thrombosis method. Finally, with regard to 30 cases of left foot and 48 cases, the ratio of R/L was obtained as 48/30, which represents the greater involvement of the left foot (table 2).

Table 1. Results Related to Observed DVT Separately for the Type of Radiology and Veins Studied

	Sonography results performed by emergency service						Sonography results performed by radiology service					
	Vein right foot		On left foot		Total two feet		Right foot vein		Left foot vein		Total two feet	
	Femoral	Popliteal	Femoral	Popliteal	Femoral	Popliteal	Femoral	Popliteal	Femoral	Popliteal	Femoral	Popliteal
Positive	9	9	24	25	33	34	6	7	22	23	28	30
Negative	21	21	24	23	45	44	24	23	26	25	50	48
Total					78	78					78	78

Compression ultrasonography performed on patients' popliteal vein with suspected deep vein thrombosis of the lower extremities showed that in 27% of the patient's popliteal vein had lost its compressibility that is the test result was positive. In complementary examination with duplex sonography, 23.8% of patients had this condition and the test result was positive. This was while compression ultrasonography performed on patients' femoral vein with suspected deep vein thrombosis of the lower extremities showed that in 26.2% of patients, the femoral vein had lost its compressibility that is the test result was positive. In complementary examination with duplex sonography, 22.2% of patients had this condition and the test result was positive (figure 2).

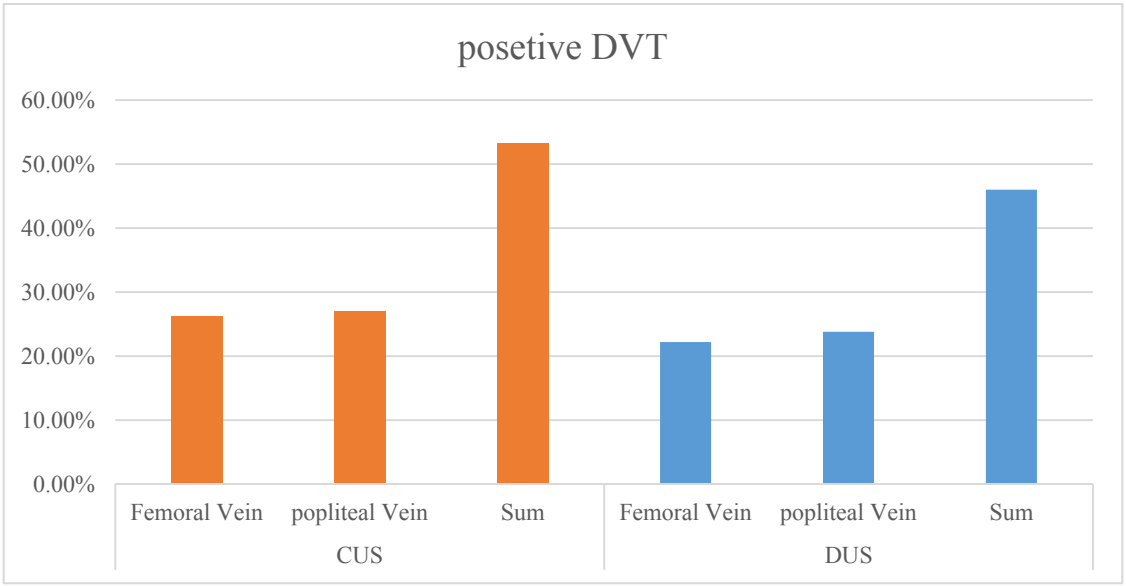

Figure 2. Frequency of Positive DVD Using CUS and DUS Methods

Of the 63 patients, 35 (55.55% of all patients) showed the lack of compressibility on the walls and impaired blood flow in the vein in examining with duplex sonography examination. Therefore, the real positive cases of this study were 35 patients. Two other patients that compression ultrasonography for them was positive did not have lower extremity deep vein thrombosis in further investigations with duplex sonography. These two cases, who formed about 3% of patients, were considered as false positive compression sonography. Of the 63 patients examined in this study, 26 patients had negative compression sonography. The results of duplex sonography showed that in 28

of these 63 patients, DVT result was positive, whereas this value was obtained as 26 for CUS, which indicates 2 false negative cases.

According to the results obtained and the equation listed in the methods, sensitivity, specificity, accuracy and predictive value of compression sonography diagnosis were evaluated. The results showed that the sensitivity of compression sonography in the diagnosis of deep vein thrombosis of the lower extremities in patients with suspected deep vein thrombosis of the lower extremities is 100% in only with femoral-vein study and 100% in only with popliteal-vein study. In general, positive test results for either the femoral or the popliteal vein made the overall result positive, and compression sonography sensitivity was obtained as 86.4%.

The specificity of compression sonography in the diagnosis of deep vein thrombosis of the lower extremities in patients with suspected deep vein thrombosis of the lower extremities is 90% in only with femoral-vein study and 91% in only with popliteal-vein study. In general, positive test results for either the femoral or the popliteal vein made the overall result positive, and compression sonography specificity was obtained as 80.4%.

According to the results of sensitivity and specificity, the accuracy of compression sonography for the diagnosis of deep vein thrombosis of the lower extremities in patients with suspected deep vein thrombosis of the lower limbs is 83.3%, and its positive and negative predictive values are 80% and 87.8%, respectively (Table 2).

Table 2. The sensitivity, specificity and predictive value of CUS

Kind of vein	Sensitivity, %	Specificity, %	PPV	NPV
Popliteal	100	91	84.8	100
Femoral	100	90	88.2	100
Total	86.6	80.4	80	86.8
Number of limbs	78			

4. Discussion

Of important DVT diagnostic methods that have great importance and use radiological procedures can be noted. The gold standard for diagnosing DVT of the lower extremities is "venography." However, today, due to being invasive and the need for intravenous contrast agents, the tendency to use this method is very low and is limited to specific cases (Jacobson, Patel, & Lewis, 1997; Theodoro, Blaivas, Duggal, Snyder, & Lucas, 2004; Tomkowski et al., 2007). Another method to detect DVT of the lower limbs is using duplex sonography. Although this method does not require contrast agent and is a non-invasive method, (Goodacre, Sampson, Thomas, van Beek, & Sutton, 2005; Kearon, Ginsberg, & Hirsh, 1998) the need to perform this test by an expert of radiology, who does not have 24-hour presence in the hospital, limits this test (Cogo, Lensing, Prandoni, & Hirsh, 1993). Compression sonography as a method free of the above-mentioned limitations can be a good alternative to the previous method as a radiological method (Goodman et al., 2007), which needs to be investigated, of course. The aim of this study is to investigate the potential of this method in DVT diagnosis.

In the present study, patients' sonography in emergency department is conducted by two physicians in emergency department – and in radiology department by radiology residents or faculty member of radiology. The number of patients in this study is 63 patients. The sample size has acceptable reliability for the results obtained. In terms of demographic characteristics, there is a difference in gender prevalence of the results of this and the results of previous studies. In most studies performed in lower limb DVT, prevalence in women has been more than in men (Dua, Desai, Nodel, & Heller, 2015; Heijboer et al., 1993). However, in this study, 47.6% of the patients were women and 52.4% of them were men. Compared to the existing studies in this regard, the average age of the patients in this study was lower than other studies (Heijboer, Cogo, Buller, Prandoni, & ten Cate, 1992; Shammas, Padaria, & Ahuja, 2015).

The important point that should be considered in the interpretation of these results is that the apparent similarity in the percentages obtained in individual and together investigations of the veins of the lower extremities does not represent the high accuracy of sonography compression.

Although compression sonography performed on femoral vein of the patients with suspected DVT of the lower extremities showed that in 26.4% of patients, the femoral vein had lost its compressibility that is the test result was positive, and in complementary investigation by duplex sonography 22.2 % of patients had this condition and the test result was positive, these percentages do not show that the positive or negative cases of compression

sonography testing are the same positive and negative cases of duplex sonography. In other words, perhaps on average of every 10 people surveyed by compression sonography 7 people, and of 10 people surveyed by duplex sonography 7 patients had a positive result in their results, but there is no guarantee that these 7 people are the same 7 people. Therefore, it is possible that three people whose compression sonography is detected as negative be detected as positive or vice versa in checking with duplex sonography. Thus, false and true positive and negative concepts were used to classify data.

In this study, sensitivity, specificity, and accuracy of compression sonography for the diagnosis of DVT of the lower extremities in patients with suspected deep vein thrombosis of the lower extremities were respectively obtained as 100%, 92.8% and 96.8% and its positive and negative predictive value were, respectively, 94.5% and 100% with a CI of 95%. Therefore, it can be concluded that the sensitivity and specificity of this test in the diagnosis of DVT of the lower extremities is good, and detection accuracy of 96.8% suggests that compression sonography can have good accuracy in the diagnosis of DVT of lower extremity, but it cannot replace more accurate methods, which are now used as available diagnostic procedures. Therefore, it seems that the helping role of this method to start or not start anticoagulant therapy for patients is good, and in the case of access to the duplex sonography, it is better for the patient's final decision to be taken after duplex ultrasonography.

Nevertheless, other studies have achieved other results. Among these studies is the study by Kline et al that in their article mentioned that despite their imagination, sensitivity and specificity of compression sonography is 70% and 90%, and, therefore, they have a moderate accuracy in diagnosis of DVT of the lower extremities (Kline, O'Malley, Tayal, Snead, & Mitchell, 2008).

The result of the diagnostic accuracy of compression sonography in our study is similar to results obtained by Jeanne Jacoby, where the compression diagnostic characteristic of sonography is obtained as 97% (Jacoby et al., 2007). Another recent study on the same issue is the study by Crisp where the sensitivity of compression sonography is obtained as 100% and specificity of compression sonography as 99.1% (Crisp, Lovato, & Jang, 2010).

According to the results of the available studies of which the present study is one, it can be concluded that compression sonography compared to selected methods of diagnosis of deep vein thrombosis of the lower extremities (duplex ultrasonography), which is considered as the alternative of gold standard (venography), has good diagnostic accuracy, and in cases when there is no access to other facilities and radiology experts is not possible, or when there is a great delay, this method is reliable and can be performed by emergency medicine specialists.

Limitations

The sample size and lack of previous studied in this issue was the limitation of this study.

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Conflict of Interest/Financial Disclosure

There is no conflict of interest or financial disclosure for this study.

Competing Interests Statement

The authors declare that there is no conflict of interests regarding the publication of this paper.

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