Real-Time B-Mode Ultrasound in the ED Saves Time in the Diagnosis of Deep Vein Thrombosis (DVT)

DANIEL THEODORO, MD, RDMS, MICHAEL BLAIVAS, MD, RDMS, SANDEEP DUGGAL, MD, GRAHAM SNYDER, MD, AND MICHAEL LUCAS, DO

We hypothesize that EPs can decrease the time to disposition when performing examinations for deep venous thrombosis (DVT) compared with disposition times using imaging specialists (IS). We performed a prospective, single-blind observational study at an academic ED over the course of 1 year. Patients were enrolled based on study physician availability. EPs ordered the corroborative ultrasound, then performed their own examination. EPs recorded patient triage time, ED results, and disposition times for both EP and IS departments. One hundred fifty-six patients were enrolled. Thirty-four (22%) were diagnosed with a DVT. Mean time from triage to EP disposition was 95 minutes and mean time from triage to radiology disposition was 220 minutes. The difference of 125 minutes was statistically significant (P <.0001). EPs and ISs had excellent agreement (kappa = 0.9). Compression ultrasound performed by EPs resulted in a significant decreased time to disposition. Agreement with ISs was excellent. (Am J Emerg Med 2004;22:197-200. © 2004 Elsevier Inc. All rights reserved.)

The physical examination is a poor predictor of the presence of deep venous thrombosis (DVT). Traditional physical examination findings such as Homan's sign, the presence of a swollen erythematous leg, and calf tenderness have sensitivities no better than a coin toss.[1,2] Ultrasound technology has simplified the diagnosis of DVT by providing real-time visualization of the presence or absence of thrombus and now is considered initial diagnostic test for DVT.[3]

In recent years, an abbreviated, bedside ultrasound technique has been accepted by EP sonographers to diagnose the presence of DVT.[4-7] Traditional lower extremity (LE) ultrasound involves an exhaustive evaluation of the femoral and popliteal veins and their tributaries. Real-time B-mode compression assesses the presence of thrombus, whereas color Doppler is applied to judge the presence of flow throughout the vessel. Spectral Doppler assesses flow rates through the vessel while the leg is compressed, in effect "augmenting" flow to ensure patency of the vessel; hence, the term "duplex ultrasound," as two modalities of ultrasound technology are used during testing. In the abbreviated version, instead of imaging the entire femoral and popliteal vein, the iliofemoral junction and the popliteal vein are evaluated.[8] Compression is applied to assess the presence of thrombus only in these regions. Color Doppler is not used to assess flow, but to assist in the detection of the vessels. The method gained acceptance after data indicated that the majority of thrombi are present at distinct venous segments.[9] This method is clinically reliable if and only if the patient has a follow-up examination in 5 in 7 days. Repeat examination is designed to diagnose a calf thrombus that could migrate proximally.[10]

This abbreviated yet accurate method supplies EPs with a quick, reliable, noninvasive test to determine the presence or absence of disease. Proponents of emergency ultrasound argue that EPs should embrace this technology to improve the care they deliver. One ED study has shown that EP-performed compression ultrasound is quick and accurate.[11] However, no study has documented whether EDs should expect significant time savings when EPs perform such studies. We hypothesized that EP-performed LE compression ultrasound results in significant time to disposition savings (defined as time to discharge or admission decision based on ultrasound results) when performed in a high-volume, suburban ED.

METHODS

Study Design

This was a single-blind, prospective, observational study of patients who presented to our ED with complaints or physical findings suggestive of LE DVT. The study used a convenience sample of patients. All patients gave consent before the ED ultrasound. The study was approved by the Institutional Review Board.

Study Setting and Population

Study subjects were enrolled over a 1-year period at a suburban tertiary care ED with a census of 70,000 patients per year. All patients who presented to the ED with symptoms suggestive of DVT were screened for study eligibility. Patients were included if (1) the ED physician felt the patient was at risk for DVT, and (2) the patient was stable to undergo noninvasive testing. Patients were excluded if (1) they had a history of a DVT diagnosed by ultrasound before ED arrival, or 2) they had a history of chronic DVT.

From the Department of Emergency Medicine, North Shore University Hospital, Manhasset, New York; and the Department of Emergency Medicine, Medical College of Georgia, Augusta, Georgia.

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Address reprint requests to Michael Blaivas, MD, RDMS, Department of Emergency Medicine, Medical College of Georgia, 1120 15th Street, AF-2039, Augusta, GA 30912-4007. Email: blaivas@pyro.net

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Study Protocol, Measures

We identified five emergency ultrasonographers who had demonstrated proficiency at LE detection of DVT by ultrasound. This group consisted of three residents, the emergency ultrasound fellow, and one attending credentialed in emergency ultrasound. When a member of the group was working and a case of suspected DVT presented, the EP was instructed to order the follow-up study and then proceed to perform his or her own abbreviated LE examination.

EPs noted the time of their diagnosis and referred to this as the "disposition time" for their patient. All patients in the study had a confirmatory study by the department of radiology. The physician responsible for the patient was then asked to note the time they were informed of the results from the radiology department. This time was referred to as the "disposition time" for the radiology department. For the purposes of the study, we took the time the EM physician received the result of the study as the disposition time from the radiology department. Time from patient triage was used as time zero for both cases. Results from both departments were noted and the radiology department study results were deferred to if results differed. The radiology department was not made aware of the EP's ultrasound findings. If the radiology department was immediately available, the ED study was halted. If this occurred, the EP was not made aware of the radiology department's findings until after the ED ultrasound was performed on the return of the patient to the ED.

Radiology-performed ultrasound examinations for excluding LE DVT were available 24 hours a day 7 days a week; however, we do not have dedicated radiology ultrasound technologists for the ED. Patients who require a radiology ultrasound are inserted into the schedule whenever time is available and typically must wait for transport to the upstairs radiology suite. Once there, they receive their study and wait for transport to return along with the radiology report. From the hours of approximately 6 PM to 8 AM, the senior radiology resident on-call performs and reads the ultrasound study. In this case, the patient is moved to a room in the ED where a radiology department ultrasound is available for the study. The results of the test are usually called in to the attending physician who ordered the test or are verbally communicated in person.

In no way did the ED examination interfere with the normal protocol of obtaining a LE compression ultrasound. Other than the authors, no ED, transport, or radiology staff knew of timing considerations. To decrease bias, the study physicians were asked to check with radiology regularly to ensure ultrasound results were obtained as quickly as possible after each radiology study was performed.

All ultrasounds by the ED were performed with Agilent Image Point Hx (Andover, MA) with a L1038 10-MHz linear probe or with a SonoSite 180 (Bothell, WA) with an L-38 10-5 MHz linear array probe. In accordance with American Thoracic Society (ATS) guidelines, EPs performed two-point compression ultrasound.[12] The iliofemoral segment was imaged to 2 cm distal to the bifurcation of the deep and superficial femoral vein, whichever came first, as previously described. The popliteal vein was next imaged in the popliteal fossa. It was followed distally until the appearance of the trifurcation. Color Doppler was used to assist the identification of the vessels. No color Doppler assessment of flow was performed.

Data Analysis

Disposition times using ED and radiology result times were compared by using the Student's t test. Correlation coefficients were calculated between EP and radiology department findings because we did not consider duplex ultrasound to represent the gold standard.

RESULTS

One hundred fifty-six patients were enrolled. 34 (22%; 95% confidence interval [CI], 15-34%) were diagnosed as having a LE DVT by EPs. Mean time from triage to EP disposition was 95 minutes and mean time from triage to radiology disposition was 220 minutes. The difference of 125 min (95% CI, 94-135) was statistically significant with a $P < .0001$. EP results agreed with radiology results in 154 of 156 cases. There was a very high correlation with radiology study results yielding a kappa of 0.9 and a 99% agreement (95% CI, 95.4-100%).

Radiology and ED ultrasound differed in two cases. In the first case, the ED ultrasound was thought to be positive. The patient was a difficult study as a result of patient habitus for both departments (communication with the radiologist after this specific case). After much debate, the radiology department found the patient to not have the presence of a thrombus but recommended follow-up examination within a few days.

The second case in which the departments disagreed was an individual with chronic DVT. The patient presented with shortness of breath, and the LE ultrasound was performed to assess the risk of pulmonary embolism. The patient had no LE symptoms. The EPs were informed of his disease after inclusion into the study. On examination, the vessels appeared thickened and not to collapse. However, radiology ultrasound believed the thickened vessels to represent chronic cannulated thrombus. In addition, on examination of the patient's two legs, one was believed to have thrombus in the popliteal fossa not noted by the EPs.

There was no difference for radiology disposition times whether performed during normal business hours or late at night. Times varied widely and were more likely to depend on individual radiology resident than time of day (informal observation). In no case was the radiology department available before the EP's ability to perform an ED study.

DISCUSSION

Approximately 500,000 people are referred for medical evaluation as a result of a suspicion of DVT each year in the United States.[13] As the number of visits to EDs continues to rise, more pressure is placed on the EP to see, diagnose, treat, and disposition patients in a timely manner.[14] As a result, efficient and safe ways to rapidly diagnose patients present an advantage for EPs who function in high-volume EDs.

Recently published studies have attempted to validate prediction rules in the diagnosis of LE DVT because the physical examination remains very unreliable.[15] Although they effectively stratify risk of DVT, they are not predictive

of disease and rely on adjunctive testing to make the final diagnosis of DVT.[16] D-dimer assays are also used in an attempt to rule out the diagnosis in low-probability patients. However, many D-dimer assays lack sufficient sensitivity to rely solely on in every case.[17,18] Although decision rule applications as well as rapid blood testing such as the D-dimer have come into clinical use as physicians attempt to close the "diagnosis gap," EPs continue to rely on LE ultrasound to evaluate potential thromboembolic disease.

As a result of time constraints in many vascular laboratories and abbreviated B-mode compression, ultrasound has been established as an effective way to diagnose DVTs.[19] Multiple large trials support that an ultrasound of the common femoral, deep femoral, and superficial femoral vein junction and popliteal region is sufficient to diagnose the presence of disease.[20] The presence of isolated thrombus not visible in either of these areas is rare.[21] Although the sensitivity of ultrasound drops when calf vein thrombosis is taken into consideration, the management of such cases remains institution-or practitioner-dependent. Validation studies using compression ultrasound indicate that patients without evidence of DVT using an abbreviated study can be safely discharged without anticoagulation as long as a second study is performed 5 to 7 days later. In Birdwell's cohort of 405 patients, repeated negative LE ultrasound had a negative predictive value of 99.4%. Only one patient was found to have had a pulmonary embolus 8 weeks after follow up, and no patient with negative LE ultrasound studies died from a pulmonary embolus at 6 months follow up.[22] In Cogo's cohort of 1,703 patients, one died of pulmonary embolism in the week between testing (despite treatment), 12 (3%) were found to have DVT at 1 week, and seven patients had a DVT at 3 months follow up. At 6 months, no patient had died from thromboembolic complications.[23]An abbreviated examination with good follow up appears to be an effective management strategy for patients who have a clinical suspicion of DVT.

Despite this evidence, many protocols for DVT diagnosis exist because some institutions are not afforded 24-hour radiology or vascular laboratory services. Some institutions place patients on intravenous heparin and admit to the hospital for a study the following day or administer one dose of low molecular-weight heparin and discharge patients to have their study arranged the next day by their primary care physician. There has been little in the literature to document the safety of preemptive systemic anticoagulation for 24 hours. This trend will continue as operating costs for vascular laboratories make 24-hour coverage prohibitive and as Medicare and Medicaid reimbursement continues to fall.[24]

Concomitantly, the role of ultrasound in the ED has grown to include the diagnosis of DVT. EPs have proven successful at diagnosing the presence of the disease in a rapid and accurate manner. In one particular study, the median time to complete a study was 3 minutes 28 seconds and the agreement with the vascular laboratory was 98%.[25] A means of rapid bedside diagnosis offers the advantage that no patient must leave the ED premises and that patients can be rapidly treated. Both of these issues take on more importance when one takes into account that there are 500,000 ultrasound examinations ordered annually to rule out DVT and that DVTs lead to pulmonary embolus and death in approximately 50,000 cases per year. The rapid disposition of patients remains a crucial issue as patient volume, patient satisfaction, and cost savings become more prominent issues within the state of modern health care.[26-28]

The purpose of our study was to illustrate that ultrasound technology in the hands of the EP is safe and efficient. To date, no study has attempted to compare real-time savings for ultrasound examinations performed by EPs with a vascular or radiology laboratory. Although our setting is in an academic center and does not reflect the situation of all EM practitioners, this study supports the notion that ultrasound in the hands of capable emergency sonologists can be efficient. In our setting, patients were dispositioned over 2 hours sooner when scanned by EPs. This suggests that ultrasound technology can have a role in improving ED efficiency, a fact that EPs cannot ignore, as ED volumes increase and emphasis is placed on reliable methods to treat and triage patients expeditiously.

Limitations and Future Questions

Our study did not use a uniform model across all cases to ensure that patients were always transported in the timeliest fashion, a potential source of bias. Typically, no extra effort is made on the part of the ED staff to expedite out of department testing, and we intended to compare models that most closely resembled everyday practice in academic settings. Although this might not resemble all ED protocols for out-of-department testing, from the authors' experience and from communication with our colleagues, we felt that our system reflected a typical ED academic setting.

This study used a criterion standard, radiology ultrasound, instead of a true gold standard as a result of lack of availability. Thus, because venography was not used, the absolute true incidence of disease is unknown. However, B-mode compression ultrasound is now the test of choice for DVT evaluation and has proved to be highly accurate when compared with venography.

Cost-effective analysis that translates across hospitals and regions would be too difficult to ascertain from a simple study. However, shorter ED stays would translate into less time invested from ED staff (nurses, aides, transporters) on patients who are waiting and more time spent on patients who require it. Also, whether rapid disposition makes an impact on the morbidity and mortality of patients with thromboembolic diseases remains to be seen. These outcomes require more investigation into emergency ultrasound.

CONCLUSIONS

Our study indicates that EPs can decrease the time to disposition decision when performing their own ultrasound examinations of the lower extremities to rule out DVT rather than relying on radiology performed studies.

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