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Brief Report

Prospective comparison of emergency physician–performed venous ultrasound and CT venography for deep venous thrombosis

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Abstract

Background: Venous thromboembolic disease is a major cause of mortality and morbidity.

Objectives: The aim of this study is to compare emergency physician–performed ultrasound (EPPU) of the lower extremities with CT venography (CTV) in emergency department (ED) patients undergoing workup for pulmonary embolism (PE).

Methods: This was a prospective study performed at a busy academic ED. Adult patients (>18) undergoing workup for PE were eligible for the study; enrollment was based on a convenience sample, during hours worked by the investigators. Study patients underwent EPPU of the lower extremities followed by CT angiogram (CTA) of the chest and CTV of the lower extremities. Sensitivity and specificity of the ultrasound examination were calculated using CTV as the gold standard.

Results: A total of 61 patients were enrolled. Of 61 patients, 50 (82%; 95% confidence interval [CI], 72%-91%) had negative workups; 11 (18%; 95% CI, 8%-27%) were noted to have PE on CTA; 6 (10%; 95% CI, 2%-17%) were noted to have lower extremity deep venous thrombosis (DVT) on both EPPU and CTV evaluation; whereas 1 patient was found to have an external iliac DVT on CTV, which was not noted on EPPU. All patients with DVT (by either EPPU or CTV) were found to have PE on CTA. Sensitivity and specificity of EPPU when compared to CTV in the diagnosis of DVT was 86% (95% CI, 42%-99%) and 100% (95% CI, 91%-100%), respectively.

Conclusions: Emergency physician–performed ultrasound produces results consistent with CTV in the diagnosis of femoropopliteal DVT. More proximal clots are not evaluated with EPPU and thus may result in a false negative.

1. Introduction

Venous thromboembolic disease continues to cause significant morbidity and mortality, affecting millions of people worldwide. It is considered to be the third most common acute cardiovascular disease after coronary artery

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disease and cerebrovascular accident [1,2]. Pulmonary embolism (PE) is the most feared complication resulting from deep venous thrombosis (DVT) with an estimated mortality rate of 25% to 30% in untreated cases [3]. Estimates of annual deaths attributable to PE in the United States range from 50 000 to 100 000 [4].

The methods used for diagnosing PE have evolved over time. Historically, ventilation-perfusion (V/Q) scans and pulmonary angiography have been used. CT angiography (CTA) of the chest is now being used extensively, largely replacing V/Q scanning and conventional angiography [5].

Because DVT and PE represent different manifestations of the same disease process, there has been increasing interest in ruling out both processes simultaneously. The concept of combining CTA examination of the chest and CT venography (CTV) of the lower extremities to exclude DVT arose in the late 1990s, with the first article on the subject published in 1998 [6].

The utility of ultrasound (US) in the assessment for DVT is well known, and the US experience predates CTV. Several studies comparing CTV with lower extremity sonography have proven that CTV is an accurate modality for the assessment of femoropopliteal DVT [7-9]. In the largest and most recent study, Goodman et al [10] examined the data collected from the PIOPED II study. More than 700 CTV and lower extremity US examinations were compared, and the study showed that there was 95.5% concordance between CTV and venous US in the diagnosis or exclusion of lower extremity DVT [10].

To our knowledge, no study to date has compared the accuracy of CTV and lower extremity venous US solely in the emergency medicine patient population. In addition, the US component of prior studies has relied on radiology-performed and interpreted examinations, and no study has utilized emergency physician–performed US (EPPU). We seek to prospectively compare the results of CTV and EPPU in emergency department (ED) patients undergoing workup for PE.

2. Methods

This was a prospective study comparing CTV to EPPU of the lower extremities in patients undergoing evaluation for a PE. The study was approved by the institutional review board and was conducted in the ED of an urban, tertiary care medical center with an annual patient volume of 78 000. The facility supports an emergency medicine residency training program and functions as a level I trauma center. Emergency physicians are offered hospital credentialing in US based on American College of Emergency Physician guidelines. Limited lower extremity venous US is part of the credentialing package and is performed in the ED by credentialed faculty to evaluate for DVT.

All adult patients undergoing workup for PE using CTA were deemed potential study candidates. Pediatric patients (<18 years of age) were excluded from the study. The decision to initiate a PE workup was left up to the discretion of the attending physician who was blinded to the US results.

A convenience sample, allowing the study investigators to perform all lower extremity venous US studies, was utilized. The study investigators consisted of an emergency medicine US fellowship director, an emergency medicine US fellow in training, and 2 credentialed faculty members who were not fellowship trained in US. Each had performed at least 100 lower extremity venous US studies before the study. Patients undergoing PE workups in the ED when a study investigator was available were eligible for enrollment in the study. Evaluation for PE on enrolled patients was initiated either by the investigators or by fellow faculty members working in the ED when an investigator was on duty. Once a decision was made by the treating ED attending physician to pursue a PE workup on a given patient, one of the investigators performed bilateral lower extremity venous US at the bedside. The results of the US examination did not affect the decision to continue the PE evaluation. All US examinations took place before the CTA, and US results were recorded immediately before the radiologist report on the CTA. The radiologist interpreting the CTA was blinded to the US results.

The US examinations were performed using either a Phillips HDI 4000 (Bothell, WA) or a SonoSite MicroMaxx (Bothell, WA) machine using a broadband linear array 12-5 MHz transducer. The limited US examination consisted of compression of 3 segments of the lower extremity venous system: (1) the common femoral vein from superior to the saphenous vein to the bifurcation, (2) the proximal superficial and deep femoral vein, and (3) popliteal vein to the trifurcation into the calf veins. Deep venous thrombosis was excluded if the lumen could be obliterated with compression (Fig. 1). The study was deemed positive for DVT if a vein could not be fully compressed (Fig. 2). Both US systems are capable of color and spectral Doppler, but the use of these techniques was not part of the protocol. No time limit was placed on the performance of the bedside US.

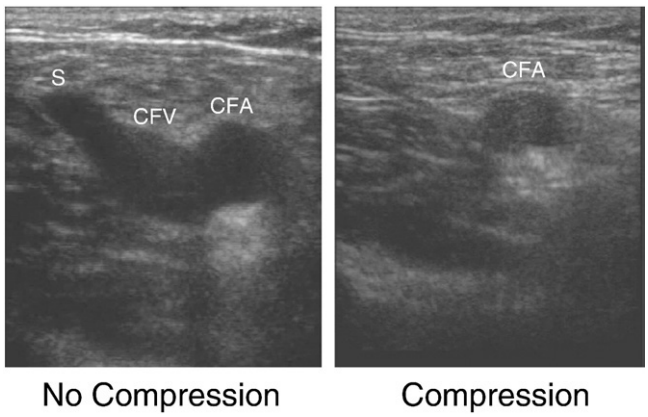

Fig. 1 Complete obliteration of the venous lumen with compression consistent with the absence of DVT. S indicates saphenous vein; CFV, common femoral vein; CFA, common femoral artery.

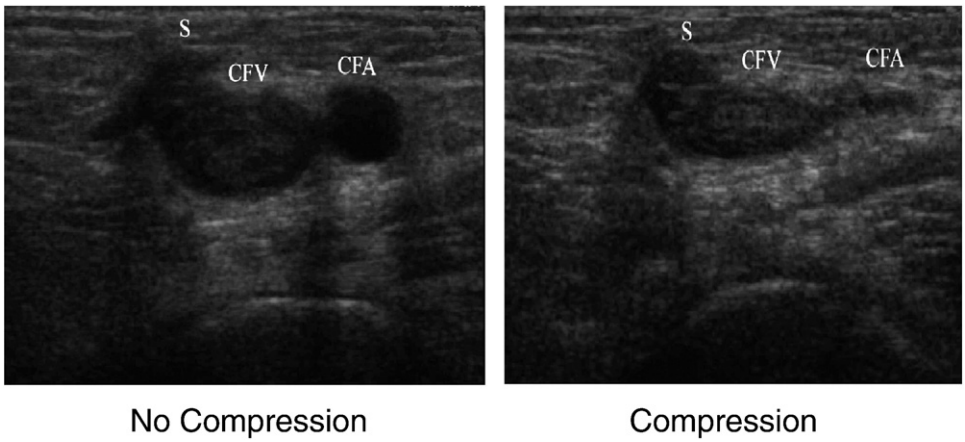

Fig. 2 Incomplete obliteration of the venous lumen with compression consistent with the presence of DVT. S indicates saphenous vein; CFV, common femoral vein; CFA, common femoral artery.

After lower extremity venous US, the patient underwent CTA of the chest and CTV of the lower extremities using a GE Lightspeed CT scanner. The CT examination was performed using 5-mm thickness, 3-mm interval cuts using 100 mL of Omnipaque 350 contrast. A DVT was diagnosed on CTV when a venous filling defect was noted (Fig. 3). CT venography is a standard part of the CT protocol for PE in our institution, and no additional contrast agent was administered for the lower extremity evaluation.

The results of the US and CT evaluations were documented on a standard data collection sheet. The CT findings were determined by an attending radiologist and represented the final radiology reading. No preliminary radiology findings were used for data comparison. Descriptive statistics were used to summarize the data using SPSS for Windows 11.5 (SPSS Inc, Chicago, IL). Continuous data are presented as means, and dichotomous data are presented as percent frequency of occurrence with 95% confidence intervals (CIs). Sensitivity and specificity are summarized with the associated 95% CIs using CTV as the gold standard.

3. Results

A total of 61 patients (female, 41; male, 20) were enrolled. The mean age of the patients was 43 years. Of those enrolled, 20 reported a history of prior thromboembolic events. No patient who was offered participation in the study refused to do so. No CTV or lower extremity US examinations were felt to be inadequate, and all performed examinations were included in the results.

Of 61 patients, 50 (82%; 95% CI, 72%-91%) had negative workups: no DVT noted on EPPU, no PE noted on CTA of

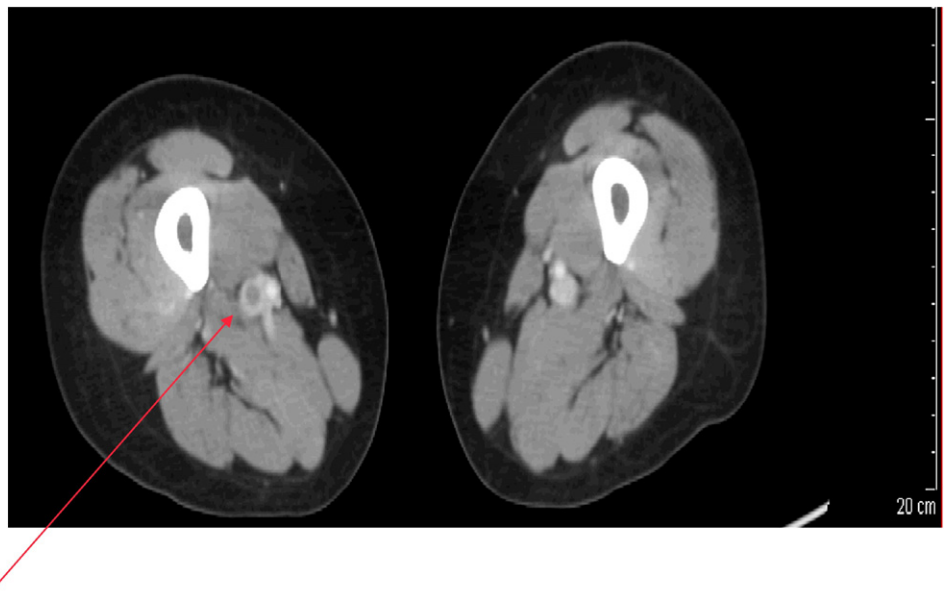

Fig. 3 Filling defect in the right popliteal vein (arrow) on CTV consistent with the presence of DVT.

the chest, and no DVT noted on CTV of the lower extremities; 11 (18%; 95% CI, 8%-27%) had evidence of PE on CTA of the chest; and 6 (10%; 95% CI, 2%-17%) were noted to have lower extremity DVT on both EPPU and CTV evaluation. One patient was noted to have an external iliac vein DVT on CTV that was not noted on US. All patients with DVT (by either EPPU or CTV) were found to have evidence of PE on CTA. The overall sensitivity and specificity of EPPU when compared to CTV in diagnosing DVT was 86% (95% CI, 42%-99%) and 100% (95% CI, 91%-100%), respectively.

Medical records of those undergoing negative workups were reviewed retrospectively to determine if there were any return visits. The average amount of time that elapsed between the original date of PE workup and the chart review was 27 months, with the shortest time being 2 months and the longest time being 43 months. No return visits in which PE was diagnosed were noted.

4. Discussion

Despite the common nature of DVT and PE, accounting for 300 000 to 600 000 hospitalizations in the United States annually, venous thromboembolic disease is quite difficult to diagnose clinically [11]. Therefore, imaging studies play a crucial role. The CTA of the chest has become the diagnostic modality of choice in the workup of PE, and US has gained preeminence in the workup for DVT. One advantage of CTV is that it may be performed concomitantly with the CTA of the chest. Typically, 100 to 150 mL of intravenous contrast agent is used with an injection rate of 4 mL/s. Thoracic images are performed 15 to 20 seconds after contrast administration, with lower extremity images being performed 3 to 4 minutes later [12]. Of note, CTV requires no additional intravenous contrast administration. Specifics of the technique and protocol may vary among institutions.

There is good data proving that the addition of a lower extremity venous system evaluation in patients undergoing PE workup increases the sensitivity for the detection of thromboembolic disease [13,14]. The PIOPED II study by Stein et al [14] showed that the sensitivity of combined CTA/CTV in ruling out PE was 90%, compared to 83% using CTA alone. Thus, concomitant evaluation of the lower extremity venous system is beneficial in setting of PE workup.

Several studies have compared CTV and lower extremity venous US in the diagnosis of lower extremity DVT. Reported sensitivity of CTV has varied between 89% and 100%, whereas specificity has ranged from 94% to 100% [1]. In addition to the excellent reported correlation between CTV and venous US in the femoropopliteal region, CTV has the advantage of providing an evaluation of proximal vasculature including the iliac veins and inferior vena cava. Isolated proximal thrombotic events have been reported so an evaluation of the more proximal system is desirable [8]. Pitfalls do exist, however, in the performance and interpretation of CTV. The most common problems appear to be related to occasional inhomogeneous appearance of the veins, which may be due to inadequate contrast administration or other technical factors. Such problems occasionally lead to a given CTV examination being labeled "indeterminant."

To date, all of the studies comparing CTV to lower extremity venous US have involved radiology performed and interpreted US evaluations. Several studies have shown that emergency physicians can accurately perform bedside lower extremity compression US to diagnose a DVT [15-19]. A recent meta-analysis done by Burnside et al [20] showed a 95% sensitivity of EPPU of the lower extremity when compared to radiology performed scans. Our study adds to the existing literature of EPPU of the lower extremity as the data show that there is excellent correlation between EPPU and CTV in the diagnosis femoropopliteal DVT, with only 1 false-negative result, which involved a thrombus located in the external iliac vein. Emergency physician–performed ultrasound does not assess the iliac veins, so the potential for a missed proximal thrombus certainly exists. Further studies are warranted to determine the frequency of such isolated proximal clots in the ED population.

Emergency physician–performed ultrasound is not without its limitations. There is no evidence at this time that EPPU can accurately differentiate between acute and chronic thrombosis. In addition, EPPU does not provide an assessment of the calf veins. CT venography may occasionally note a thrombosis distal to the trifurcation of the popliteal vein, but the absence of this finding certainly does not rule out distal thrombosis. Currently, there is no consensus on the clinical significance of calf vein thrombosis and no agreement on what, if any, treatment is warranted [21,22]. The most recent study done by Bernardi et al [23] demonstrated that the 2-point compression US and whole-leg-color–coded comprehensive US are equivalent for diagnosing lower-extremity DVT. The authors concluded that whole-leg color-coded US might lead to unnecessary anticoagulation of small calf DVT that might otherwise resolve spontaneously [23]. The issue of calf vein thrombosis remains controversial.

Limitations

The study investigators have significant experience in EPPU, each having performed greater than 100 lower extremity venous US evaluations. All of the US evaluations were performed by the study investigators, and given the inherent operator dependent nature of US, it is not clear if the results could be replicated using less experienced sonographers.

The sample size is small, and it is possible that the reported concordance between CTV and EPPU of the lower extremity might change if large numbers of patients were studied. Because of the convenience sample, it is also possible that the subset of patients included in the study does

not accurately represent the larger ED population undergoing workup for PE.

The charts of those patients undergoing negative workups for PE and DVT were reviewed retrospectively to determine if there were any subsequent visits to the hospital that resulted in a diagnosis of thromboembolic events, suggesting a false-negative original result. However, it is possible that a given patient might have presented to a different hospital with a thromboembolic complication.

We chose to use CTV as the gold standard. Prior studies have shown that there is excellent correlation between radiology-performed US and CTV in the diagnosis of lower extremity DVT [10]. Thus, comparing EPPU to CTV, using CTV as the gold standard, is reasonable. One could argue, however, that a formal radiology-performed lower extremity venous US would have been a better gold standard.

5. Conclusions

Excellent correlation exists between EPPU of the lower extremity and CTV in the diagnosis of femoropopliteal DVT. Proximal thrombotic events, such as those involving only the iliac venous system, may produce false-negative results on EPPU, whereas CTV provides an assessment of the proximal venous system. Larger studies comparing EPPU and CTV are needed to determine the frequency of such proximal thrombotic events in the ED population.

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