Journal of Medical Ultrasound (2011) **19**, 103—108

Available online at www.sciencedirect.com

SciVerse ScienceDirect

journal homepage: www.jmu-online.com

SHORT COMMUNICATION

Extended Compression Ultrasound Performed by Emergency Physicians: A Modified Compression Ultrasound Examination to Detect Superficial and Deep Lower Limb Thromboses in the Emergency Department

Alfredo Barillari [1]*, Giovanni Barillari [2], Samantha Pasca [2]

[1] *Emergency Department, ASS 2 Isontina, 34074 Monfalcone (GO), Udine, Italy, and* [2] *Center for Hemorrhagic and Thrombotic Diseases, University Hospital, Udine, Italy*

Received April 6, 2011; accepted June 1, 2011
Available online September 29, 2011

KEY WORDS
compression ultrasound,
deep vein thrombosis,
extended compression ultrasound,
superficial vein thrombosis

Compression ultrasound (CUS) is being used by an increasing number of emergency physicians for patients with suspected symptomatic deep venous thrombosis (DVT). Both the two-point and three-point CUS examinations are used with excellent sensitivity to rule out DVT. This technique has some limitations: distal DVTs are difficult to detect, and therefore a second examination is required about 1 week later to look for proximal progression of thrombosis. Furthermore, the superficial veins of the lower limbs are not routinely visualized when CUS examination is performed in the emergency department. Superficial vein thrombosis is common and has long been considered as a benign disease, however, this concept has been challenged. Superficial vein thrombosis can extend into the deep vein system and cause either DVT or pulmonary embolism.

At our institutions, we have developed a modified CUS examination for the lower limbs, which we have called extended CUS, because it explores both the proximal deep veins and superficial veins.

In this article, we describe this examination technique.

* Correspondence to:
E-mail address: alfredobarillari@gmail.com (A. Barillari).

0929-6441/$36
doi:10.1016/j.jmu.2011.08.005

Introduction

The management of patients presenting to hospital emergency departments (EDs) with suspected deep venous thrombosis (DVT) is sometimes problematic when patients present outside regular hospital staff working hours, because diagnostic imaging capability is usually not immediately available.

Symptoms and signs of DVT are nonspecific and found in a wide variety of nonthrombotic disorders, therefore, timely diagnostic testing must be performed to identify correctly patients with this condition [1].

Physical examination is a poor predictor of the presence of 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 [2].

Compression ultrasound (CUS) venous imaging is the most accurate noninvasive test for the diagnosis of DVT. In the medical literature, two modalities of this technique have been described [3]. In two-point CUS, the ability of the ultrasound probe to compress the common femoral vein (CFV) and popliteal vein (PV) is assessed by using B-mode imaging. Normal veins are easily compressible, whereas those containing thrombi are not. If both the CFV and PV are compressible, the examination is considered negative [4,5]. CUS for DVT of the lower limbs also consists of a three-point examination of the CFV, the femoral vein (FV) — previously called the superficial femoral vein, and the PV. Several studies have shown that omitting the FV and evaluating only the CFV and PV can lead to a decrease in sensitivity because isolated thrombosis of the FV occurs in 4—6% of cases [6].

Although duplex ultrasound continues to be widely used by radiology and vascular departments to evaluate proximal DVT, the early literature clearly demonstrates that limited CUS examination of symptomatic ambulatory patients when performed by expert sonographers is highly accurate in confirming or excluding the diagnosis. This technique, when compared to venography, has proven to be 100% sensitive and 99% specific for the diagnosis of proximal DVT [4]. With CUS, compressibility is evaluated in the transverse view. The entire proximal deep venous system between the proximal CFV and the trifurcation of the PV in the calf is evaluated for compressibility at 1-cm intervals. Ultrasonography results are considered abnormal if a vein or venous system is not fully compressible [3—6]. However, the limited CUS modalities, either the 2-point or 3-point techniques, do not include the superficial venous system of the lower limbs, therefore excluding an important source of systemic emboli. Superficial venous thrombosis (SVT) of the lower limbs is common, with an annual incidence estimated to be higher, although never properly investigated, than that of DVT, which exceeds 1 per 1000 persons. SVT of the greater saphenous vein (GSV) has been shown to be associated with an unexpectedly high risk of venous thromboembolic complications, that is, extension to the CFV, noncontinuous DVT, and pulmonary embolism (PE) [7]. The decision to treat SVT actively is prompted mainly because of potential extension into the deep venous system and further embolization into the pulmonary circulation [8].

At our institutions, we have developed a modified CUS examination for the lower limbs, which we have called extended CUS (*e*-CUS), because it explores both the proximal deep veins and superficial veins. In this article, we describe this examination technique.

Examination technique

The *e*-CUS modality of lower limb investigation has been developed and used at our institutions since 2006 by two expert sonographers (AB and GB). It consists of a three-point CUS examination of the proximal deep leg veins, extended to the GSV and lesser saphenous vein (LSV). It is a very simple and reliable examination that allows us to confirm or exclude DVT and SVT, using vein noncompressibility as the standard criterion to diagnose thrombosis.

The patient is placed in the supine position with the symptomatic leg externally rotated. The deep and the superficial vein systems of both legs are investigated with a 5- or 7.5-MHz linear array transducer. The compressibility in the transverse plane of the vein is assessed by simply pressing on the vessel at 1-cm intervals with the transducer probe, while observing changes in the caliber of the vein on the video monitor. Failure to compress the lumen of the vein during compression with the probe is the sole criterion for the presence of vein thrombosis [9—11].

For the assessment of the proximal deep venous system, the CFV, FV and PV of the symptomatic leg are scanned. The examination is begun, in transverse view, at the level of the inguinal crease where the CFV is identified and followed until it branches into the deep femoral and FV (Fig. 1). The FV is followed until it deepens into the adductor canal at the medial lower third of the thigh (Fig. 2).

The PV is examined with any of the following approaches: the patient in the supine position with the knee slightly flexed and externally rotated; the decubitus position; the prone position; or with the patient seated on the examination table, with the leg in a dependent position off the table (Fig. 3). The PV is identified as superficial and lateral to the popliteal artery [12].

For assessment of the GSV and LSV, the procedure of compressibility at 1-cm intervals is extended from the saphenous—femoral and saphenous—popliteal junctions, respectively, distally along the veins [5]. The GSV is explored from the level of the saphenous—femoral ligament, just below the inguinal crease, along the medial surface of the leg until the medial malleolus (Fig. 4). The LSV is followed from the saphenous—popliteal junction, on the posterior surface of the calf, distally to the Achilles tendon (Fig. 5).

This technique, in our experience, can be performed in a quick and accurate manner as the standard CUS examination, and is easily reproducible and broadly available. Its major limitation is the need to repeat the test after one week in symptomatic patients with normal findings at presentation to detect calf DVT extending to the proximal veins [1,9].

Discussion

In the ED, patients with suspected DVT are stratified with pre-test probability scores, and the disease is ruled in or

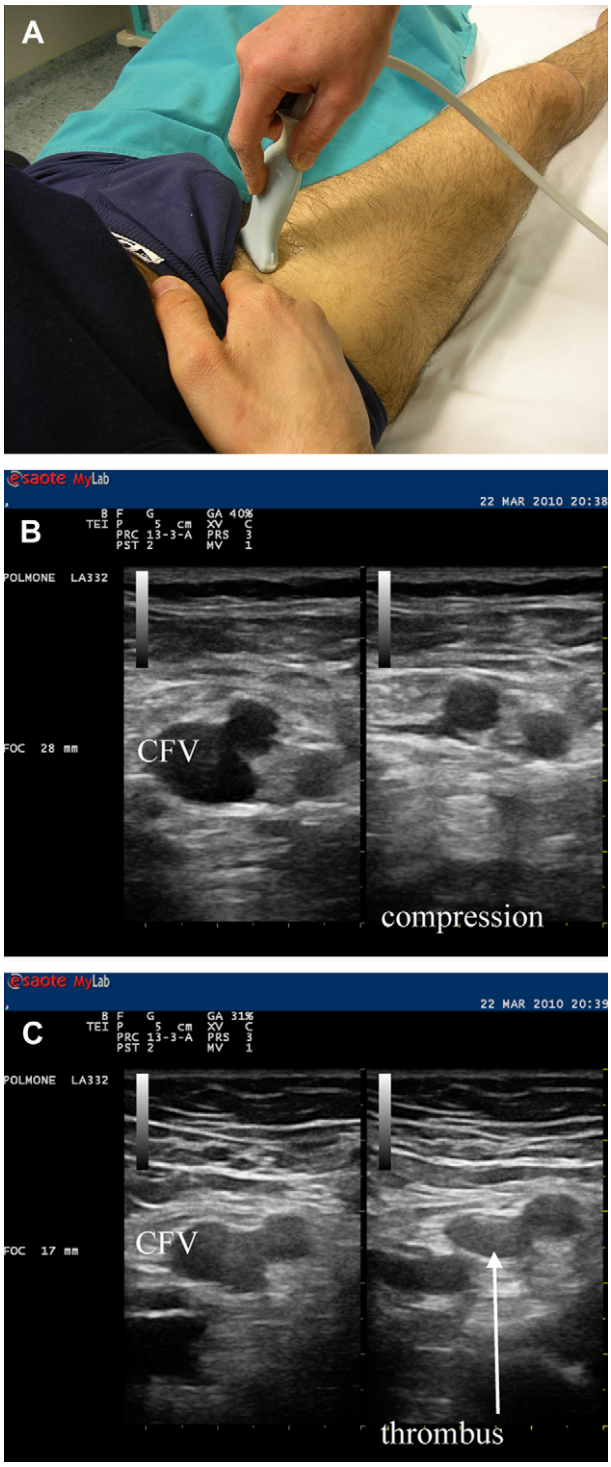

Fig. 1 (A) The examination starts below the inguinal crease to detect the CFV. The vein is scanned with the probe in the transverse position. (B) Normal finding of compressibility of the CFV. (C) Noncompressibility (thrombosis) of the CFV. CFV = common femoral vein.

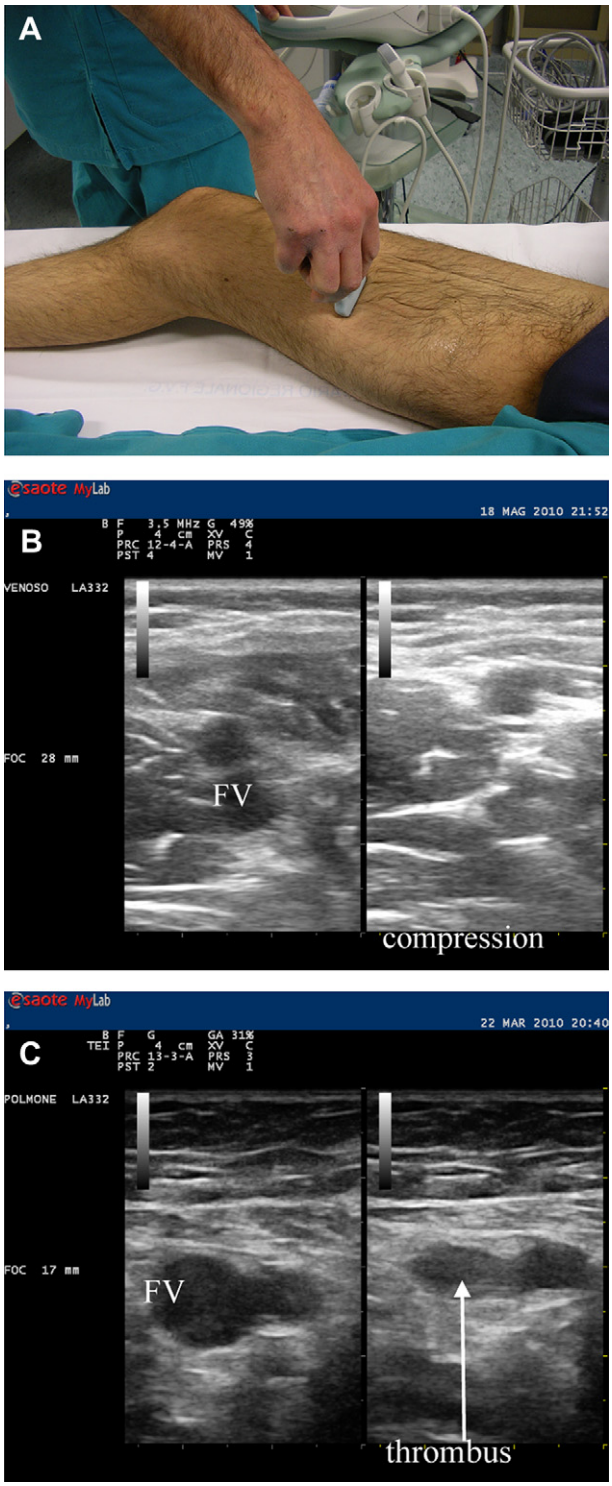

Fig. 2 (A) The FV is followed until it deepens into the adductor canal. (B) Normal finding of compressibility of the FV. (C) Noncompressibility (thrombosis) of the FV. FV = femoral vein.

out with D-dimer testing and CUS. It has been repeatedly demonstrated that the diagnosis of DVT on the basis of clinical signs and symptoms in outpatients is unreliable. For ED patients with unexplained lower extremity pain and swelling, the current diagnostic state of the art is to obtain a lower extremity CUS examination to exclude DVT before patient disposition. The role of ultrasound in the ED has grown to include the diagnosis of DVT.

In the CUS technique, noncompressibility of a segment of the deep venous system is the sole criterion for diagnosis

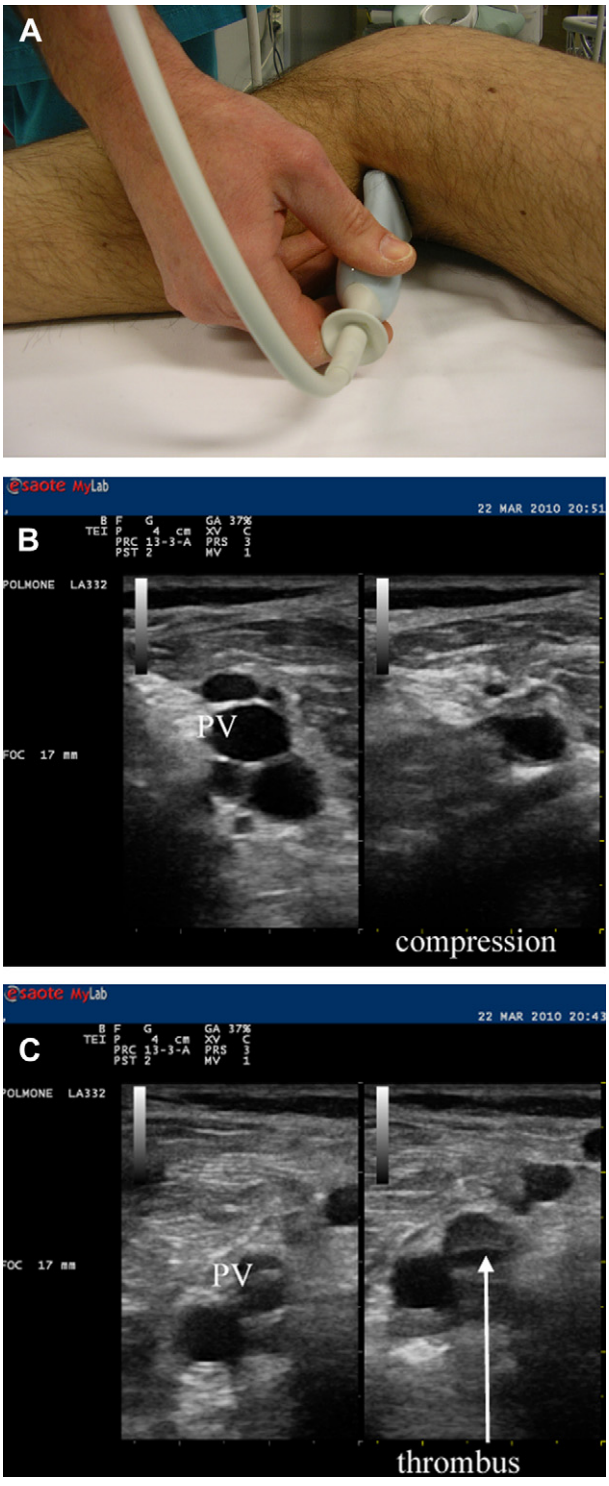

Fig. 3 (A) The PV is identified as superficial to the popliteal artery. The patient may lie supine or prone. (B) Normal finding of compressibility of the PV. (C) Noncompressibility (thrombosis) of the PV. PV = popliteal vein.

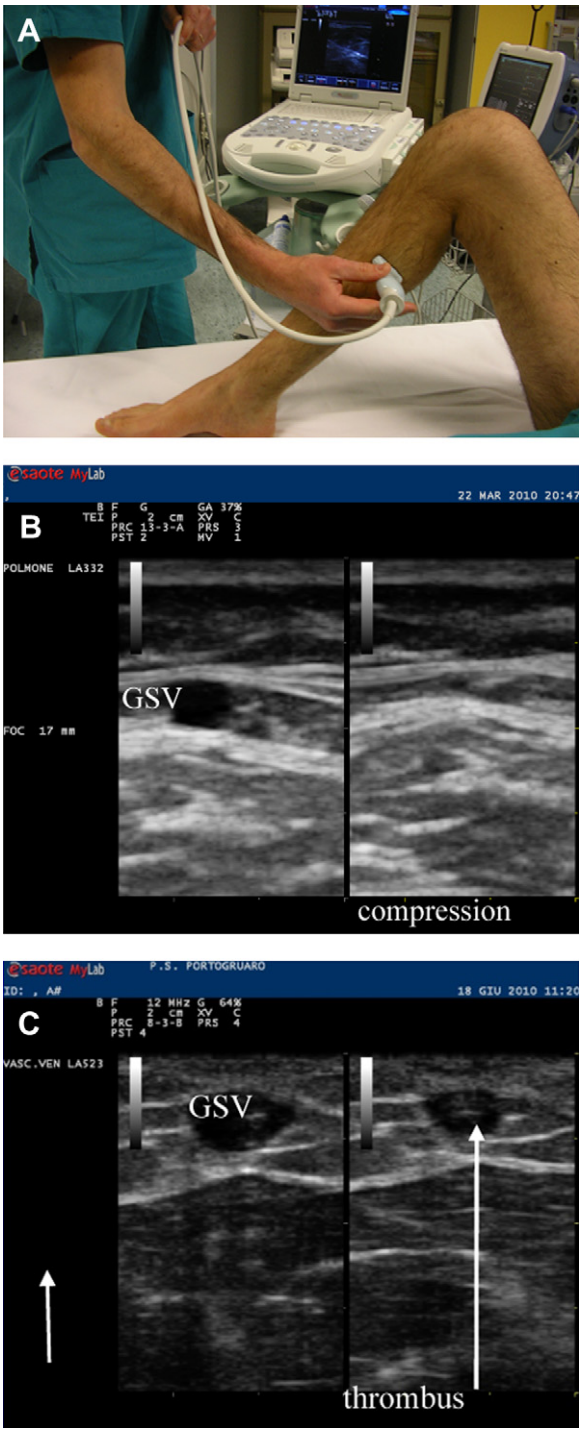

Fig. 4 (A) The GSV followed on the medial aspect of the leg, from the inguinal crease to the medial malleolus. (B) Normal finding of compressibility of the GSV. (C) Noncompressibility (thrombosis) of the GSV. GSV = greater saphenous vein.

of DVT. The sensitivity and specificity exceeds 97% for the diagnosis of DVT involving the proximal leg veins [13—16]. Little is known about SVT: there are no validated risk scores, D-dimer testing is unreliable, and CUS of the GSV and LSV is not routinely performed in the ED [6]. SVT of the lower limbs is perceived as trivial and benign, but coexistence of DVT, propagation to popliteal or femoral DVT, and even PE have been reported [12]. It may be associated with hypercoagulability due to systemic disorders or neoplastic disease, and it may cause PE, progress to other veins and to the deep system, causing DVT [17]. Studies suggest that the frequency of association between SVT and DVT ranges from

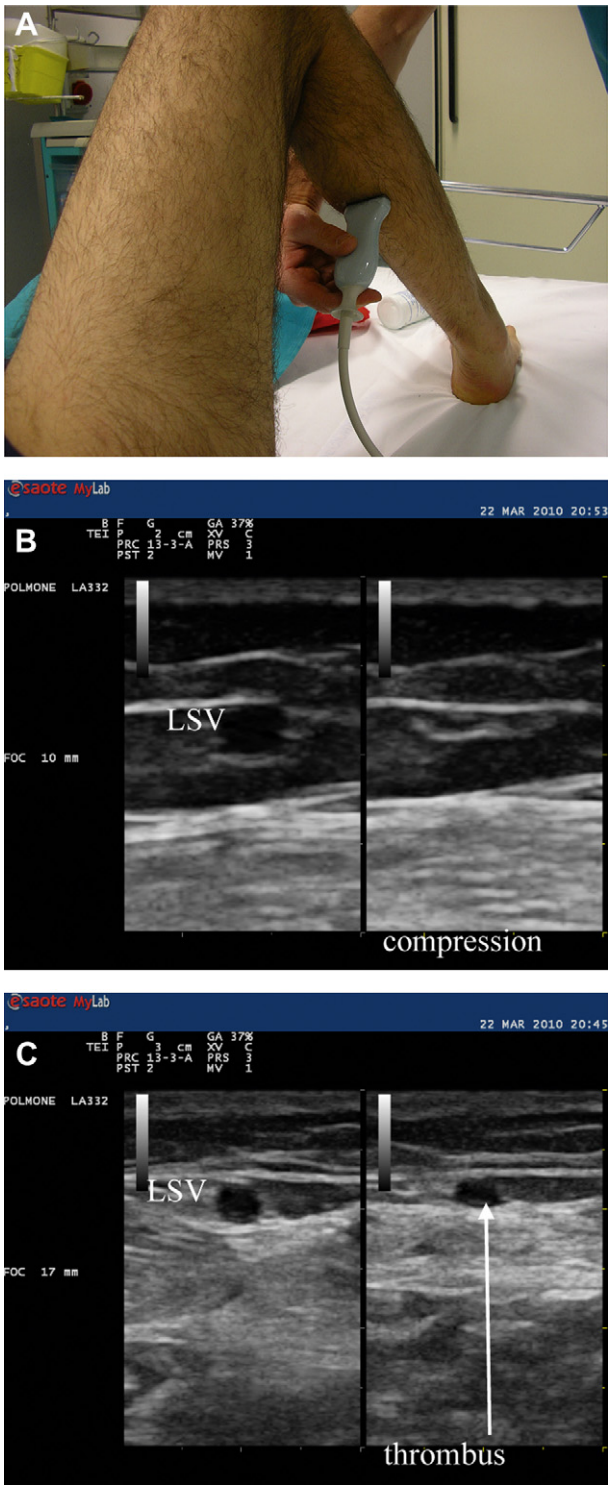

Fig. 5 (A) The LSV is scanned on the posterior surface of the calf, from the popliteal area to the lower third of the calf. (B) Normal finding of compressibility of the LSV. (C) Non-compressibility (thrombosis) of the LSV. LSV = lesser saphenous vein.

3% to 40%. Furthermore, scintigraphic data have revealed asymptomatic embolism in at least one-third of patients with SVT [6,8,18]. Contrast venography, the reference method for DVT, is not indicated in suspected SVT. It does not visualize the superficial venous system of the lower limbs, therefore, only duplex ultrasonography is used in vascular clinics for leg vein scanning [6].

Being aware of the complications and underestimation of the clinical relevance of SVT, we have widened the use of the CUS technique to the superficial venous system and have named this examination *e*-CUS. The *e*-CUS examination couples the compression technique to evaluate the proximal deep veins and the superficial venous system: the deep venous system scanned comprises the CFV, FV and PV, whereas the superficial venous system includes the GSV and LSV. We termed this examination "extended" because the term CUS refers only to the limited examination of the proximal deep veins, therefore overlooking an important source of systemic emboli. To the best of our knowledge, this extended technique has been used so far only by two authors of the present article, who are experienced sonographers. *e*-CUS can be performed rapidly and without the need for special equipment, provided that the study is restricted to the proximal and superficial venous system. The inability to compress completely the vein lumen is the principal criterion for the diagnosis of DVT and SVT [15]. We believe that the *e*-CUS examination should become an ordinary tool for emergency physicians (EPs) to evaluate the superficial and deep venous systems of the legs, but so far there are few data on CUS performance by EPs. Kline et al have reported that EP-performed CUS has potential clinical utility, although they have found that EP-performed CUS by a group of providers with limited training in this technique has intermediate diagnostic accuracy [19].

CUS as well as *e*-CUS still have some limitations: they are unable to detect isolated thrombi in the iliac vein and in the FV segment within the adductor canal. However, several studies have demonstrated that such isolated proximal thrombi are extremely rare in symptomatic outpatients, and therefore the test must be repeated after one week in symptomatic patients with normal findings at presentation, to detect calf DVT extending to the proximal veins (serial ultrasonography) [8].

Here, we have described an examination technique that, to the best of our knowledge, has not been widely used in the ED to date. The authors hope that this examination may become an important diagnostic tool for EPs. To confirm or refute the clinical utility of this approach, widespread use and further clinical studies should be conducted in ED settings.

References

[1] Wells PS, Anderson DR, Rodger M, et al. Evaluation of D-dimer in the diagnosis of suspected deep-vein thrombosis. N Engl J Med 2003;349:1227—35.
[2] Theodoro D, Blaivas M, Duggal S. Real-time B-mode ultrasound in the ED saves time in the diagnosis of deep vein thrombosis. Am J Emerg Med 2004;22:197—200.
[3] Anderson DA, Wells PS, Stiell I, et al. Thrombosis in the emergency department. Arch Intern Med 1999;159:477—82.
[4] Frazee BW, Snoey ER, Levitt A. Emergency department compression ultrasound to diagnose proximal deep vein thrombosis. J Emerg Med 2001;20:107—11.
[5] Prandoni P, Tormene D, Pesavento R; Vesalio Investigators Group. High vs. low doses of low-molecular-weight heparin for

the treatment of superficial vein thrombosis of the legs: a double blind, randomized trial. J Thromb Haemost 2005;3:1152—7.
[6] Hamper UM, DeJong MR, Scoutt LM. Ultrasound evaluation of the lower extremity veins. Radiol Clin North Am 2007;45:525—47.
[7] Marchiori A, Verlato F, Sabbioni P. High versus low doses of unfractionated heparin for the treatment of superficial thrombophlebitis of the leg. A prospective, controlled, randomized study. Haematologica 2002;87:523—7.
[8] Quenet S, Laporte S, Décousus H, et al. Factors predictive of venous thrombotic complication in patients with isolated superficial vein thrombosis. J Vasc Surg 2003;38:944—9.
[9] Bernardi E, Camporese G, Buller HR, et al. Serial 2-point ultrasonography plus D-dimer vs whole-leg color-coded doppler ultrasonography for diagnosing suspected symptomatic deep vein thrombosis. JAMA 2008;300:1653—9.
[10] Lensing AWA, Prandoni P, Brandjes D, et al. Detection of deep-vein thrombosis by real-time B-mode ultrasonography. N Engl J Med 1989;320:342—5.
[11] Bounameaux H, Righini M, Perier A. Diagnosing deep vein thrombosis: the case for compression ultrasonography limited to the proximal veins. J Thromb Haemost 2004;2:2260—1.
[12] Daniel KR, Jackson RE, Kline JA. Utility of lower extremity venous ultrasound scanning in the diagnosis and exclusion of pulmonary embolism outpatients. Ann Emerg Med 2000;35: 547—54.
[13] The Superficial Thrombophlebitis Treated by Enoxaparin Study Group. A pilot randomized double-blind comparison of a low-molecular-weight heparin, a nonsteroidal anti-inflammatory agent, and placebo in the treatment of superficial vein thrombosis. Arch Intern Med 2003;163:1657—63.
[14] Righini M, Paris S, Le Gal G, et al. Clinical relevance of distal deep vein thrombosis. Thromb Haemost 2006;95:56—64.
[15] Fraser JD, Anderson RA. Deep venous thrombosis: recent advances and optimal investigation with US. Radiology 1999; 211:9—24.
[16] Subramaniam RM, Heath R, Chou T, et al. Deep venous thrombosis: withholding anticoagulation therapy after negative complete lower limb US findings. Radiology 2005;237: 348—52.
[17] Incandela L, De Sanctis MT, Cesarone MR. Treatment of superficial vein thrombosis: clinical evaluation of essaven gel. A placebo-controlled, 8-week, randomized study. Angiology 2001;52(Suppl. 3):S69—72.
[18] Blatter W, Schwarzenbach B, Largiadér J. Superficial vein thrombophlebitis-serious concern or much ado about little? VASA 2008;37:31—8.
[19] Kline JA, O'Malley PM, Tayal VS. Emergency clinician-performed compression ultrasonography for deep venous thrombosis of the lower extremity. Ann Emerg Med 2008;52: 437—45.