Charles E. Spritzer, MD
Michael A. Arata, MD
Kelly S. Freed, MD

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Abbreviation:
DVT = deep venous thrombosis

[1] From the Department of Radiology, Duke University Medical Center, Box 3808, MRI Section, Rm 1800, Durham, NC 27710. From the 1997 RSNA scientific assembly. Received June 13, 2000; revision requested July 24; revision received September 14; accepted September 19. **Address correspondence to** C.E.S. (e-mail: *chuck.spritzer@duke.edu*).

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Isolated Pelvic Deep Venous Thrombosis: Relative Frequency as Detected with MR Imaging[1]

PURPOSE: To determine the relative frequency of deep venous thrombosis (DVT) isolated to the pelvic veins, as demonstrated with magnetic resonance (MR) imaging.

MATERIALS AND METHODS: The reports of 769 MR examinations performed from June 1993 through December 1999 in patients with suspected DVT were reviewed retrospectively. MR venography was performed by using a two-dimensional gradient-recalled-echo sequence (typically repetition time, 34 msec; echo time, 13 msec; flip angle, 60°). The presence of DVT was categorized by location in the pelvis, thigh, or calf.

RESULTS: DVT was identified in 167 (21.7%) of the 769 MR examinations. Thirty-four (20.4%) of the 167 studies demonstrated DVT isolated to the pelvic veins.

CONCLUSION: The relative frequency of isolated pelvic DVT detected with MR venography was higher than that reported in prior studies with ultrasonography (US) or ascending venography. MR venography should be performed in patients with suspected pelvic DVT or when clinical suspicion persists despite a negative US study.

Deep venous thrombosis (DVT) is a common disease occurring in approximately 500,000–600,000 patients annually (1). In addition to the morbidity directly related to venous thrombosis, DVT results in an increased risk of pulmonary embolism. Pulmonary emboli are estimated to result in 10,000–30,000 deaths annually. The majority of embolic events are due to thrombus arising from the veins of the pelvis and lower extremities. Most thrombi are presumed to arise in the calf veins (1–3). The calf thrombus then propagates proximally over time. With propagation into the larger veins of the thigh and pelvis, the risk of pulmonary embolism increases (1–3).

Isolated pelvic DVT is thought to be uncommon, accounting for approximately 2% of lower extremity DVT (4,5). Ultrasonography (US) is limited in the evaluation of pelvic veins (4,6). The relative infrequency of isolated pelvic DVT forms the basis for using duplex Doppler US to identify femoral and popliteal clots. US is a highly accurate and inexpensive imaging modality for the detection of such thrombi and is the current modality of choice for the evaluation of suspected lower extremity DVT (6,7).

Alternative modalities for the identification of thrombus include conventional ascending venography and magnetic resonance (MR) venography. Ascending venography, while long considered the standard of reference for the diagnosis of DVT, is perceived as invasive and therefore is less routinely used. More important, assessment of the pelvic veins may be technically challenging (8).

MR venography is a noninvasive imaging modality that enables direct visualization of pelvic vessels. Several authors (9–11) suggest it as the reference standard for the evaluation of pelvic thrombus.

We postulated that the true relative frequency of isolated pelvic DVT is underestimated with duplex Doppler US and ascending venography and that the superior imaging of pelvic vessels with MR venography would allow a more accurate determination of its true

relative frequency. It was the purpose of this study to determine the relative frequency of isolated acute pelvic DVT on the basis of a retrospective review of our institution's considerable accumulated experience with MR venography in the evaluation of patients with suspected DVT.

MATERIALS AND METHODS

Our MR database identified 796 consecutive studies performed for the evaluation of pelvic and lower extremity DVT from June 1, 1993, to December 31, 1999. The reports of these studies, as in our database, and not the images themselves were reviewed. Our institutional review board did not require its approval or patient informed consent for a study of this type at the time the information was reviewed. Ten of these patients have been described previously (12). Of the 796 studies, 27 examinations were performed explicitly to follow up previously documented venous thrombus and were excluded from further analysis, resulting in a total of 769 examinations performed in 742 patients (323 men, 419 women; mean age, 53 years; age range, 11–89 years). A total of 24 patients had two (21 patients) or three (three patients) MR examinations performed for the onset of new symptoms. The interval between successive examinations was 1–34 months, with a mean of 10.6 months and a median of 6.5 months. Patients underwent MR venography when proximal or calf DVT was clinically suspected, when exclusion of thrombus in the entire lower extremity and pelvis was desired, and when US was inconclusive or technically limited. Typical symptoms included unilateral or bilateral lower extremity edema, erythema, tenderness, or swelling; dyspnea; frank chest pain; or abnormal oxygen saturation in which pulmonary embolism was suspected but a definitive study of the lungs was deferred.

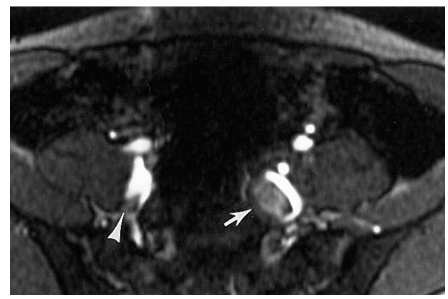
All MR venographic examinations were performed with a 1.5-T unit (Signa; GE Medical Systems, Milwaukee, Wis) whose software and hardware had been upgraded over the study period. All patients were examined from the distal inferior vena cava to the popliteal trifurcation. For the first 5 years of data acquisition, a transmit and receive body coil was used. Subsequently, a multistation receive-only phased-array lower extremity coil (Medical Advances, Milwaukee, Wis) was routinely used. This coil contains three phased-array imaging areas that cover the pelvis, thighs, and calves.

Sequential transverse gradient-recalled-echo imaging with use of 5-mm sections at 10-mm intervals was performed with a 24–36-cm field of view. Typical imaging parameters were 33–34/13 (repetition time msec/echo time msec), a 60° flip angle, and a 256 × 128 matrix. Gradient moment nulling was used in all instances. With the body coil, four signals were acquired in the pelvis and two were acquired in the thigh. By using the phased-array lower extremity coil, the number of signals acquired was reduced to two in the pelvis and to one to two in the thigh (9,13). Respiratory compensation was routinely used in the pelvis. The protocol used has been validated in prior studies (9,13,14), and the rationale for the chosen imaging parameters is available in those reports.

At our institution, MR imaging of the entire calf is performed when therapy would be initiated for thrombus isolated to this region. In the calf, 130 examinations were performed by using a head receive and transmit coil, an extremity receive and transmit coil, or the lower portion of the extremity phased-array coil described earlier. Sequential transverse images were acquired with a 5-mm thickness at 10-mm intervals. The field of view varied from 16 to 30 cm, with matrices varying from 256 × 128 to 256 × 256. To accommodate slow flow, the repetition time was increased to 75 or 100 msec. The echo time was 13 msec and one to two signals were acquired. Additional pulse sequences such as phase contrast, spin echo, or fast spin echo were performed at the discretion of the interpreting radiologist.

Cases were called positive for DVT if there was complete obstruction or near complete obstruction of a distended vein by a low-signal-intensity intravascular mass on the gradient-recalled-echo images (13,14) (Figure). Vessel abnormalities indicative of prior venous thrombus, such as webs, focal or diffuse wall thickening, and reduced vessel caliber, were considered negative for acute DVT for the purposes of this study (12).

The cases positive for DVT were categorized by location of thrombus. Specifically, six locations of thrombus were defined: (*a*) isolated to the calf, (*b*) isolated to the thigh (femoral and/or popliteal venous system), (*c*) isolated to the pelvis (inferior vena cava and iliac venous system), (*d*) calf and thigh (calf veins and femoral and/or popliteal venous system), (*e*) thigh and pelvis (femoral and/or popliteal and iliac venous system), and (*f*) entire lower extremity (ie, calf, thigh, and pelvis). Isolated involvement of the pelvic veins was further categorized into isolated external iliac vein, internal iliac vein, common iliac vein, or involvement of the common iliac vein and involvement of either or both the external iliac vein and the internal iliac vein. Presence of clot in the inferior vena cava or gonadal vessels also was noted.



Transverse gradient-recalled-echo MR image (34/13, 60° flip angle) of the pelvis in a 19-year-old woman with pleuritic chest pain and hemoptysis. The patient was taking birth control pills. Subsequent work-up demonstrated activated protein C resistance. Acute thrombus (arrow) is seen in the left common iliac vein. A focal area of decreased signal intensity in the right iliac vein is a combination of flow artifact (arrowhead) and partial-volume artifact; this finding was confirmed on more caudal images (not shown).

For those cases with acute thrombus isolated to the pelvis and detected with MR venography, the hospital database was searched for correlative duplex Doppler US examinations performed within 48 hours.

RESULTS

Acute DVT was identified in 167 of the 769 MR examinations, for a prevalence of 21.7%. Thrombus was isolated to the pelvis in 34 cases, representing 20.4% of the total positive examinations. Isolated thrombus in the thigh was more common, seen in 49 cases (29.3%), and thrombus isolated to the calf was detected in another 23 cases (13.8%). Thrombus isolated to the pelvis and thigh was present in 27 cases (16.2%) and resided in the thigh and calf in another 22 cases (13.2%). Thrombus involved the entire lower extremity in 12 cases (7.2%).

Thrombus confined to the pelvis was most often seen in the external iliac vein (Table). In 14 (41%) of the 34 examinations positive for isolated pelvic DVT, only the external iliac vein was abnormal; these 14 cases represented 8.4% of all positive cases in this series. Isolated

Relative Frequency of Isolated Pelvic DVT by Location

Vein Location	No. of Cases	Percentage of Pelvic DVT Cases (n = 34)	Percentage of Total DVT Cases (n = 167)
Inferior vena cava	2	6	1.2
Common iliac	8	24	4.8
External iliac	14	41	8.4
Internal iliac	2	6	1.2
Common and external or internal iliac	7	21	4.2
Gonadal	1	3	0.6

common iliac thrombosis was found in eight cases (24%). Clot involving the common iliac vein and external or internal iliac vein was present in seven cases (21%). Thrombus occurring solely in the internal iliac vein was seen in two cases (6%). In two additional cases (6%), thrombus was confined to the inferior vena cava: The thrombus was infrarenal in one instance and suprarenal in the other. The last case of pelvic DVT was identified in a gonadal vein (3%) in a patient who had recently undergone a cesarean section.

Duplex Doppler US of the lower extremities was performed in seven of the 34 patients in whom MR venography demonstrated isolated pelvic DVT. Each US examination was performed prior to and within 24 hours of the subsequent MR examination. In one patient, the US report commented on changes consistent with chronic DVT in the thigh but explicitly excluded acute thrombus. The report of the corresponding MR venographic examination indicated chronic changes in the left thigh and acute thrombus in the pelvis. In the six remaining cases, in which MR venography helped identify isolated acute thrombus in the pelvis, the US studies were interpreted as normal in each instance.

DISCUSSION

DVT is a common disease that requires accurate imaging for diagnosis (1,7,15,16). In most cases, such thrombus is believed to originate from the calf veins. The major sequela of lower extremity DVT is pulmonary embolus. Although debated, thrombus becomes clinically important as it extends into the femoropopliteal and iliac veins (15). Support for the concept of clot propagation arising in the calf is presented by numerous authors (1,5) who used a variety of imaging techniques. In the absence of predisposing factors such as trauma, pelvic malignancy, or hematoma, the relative frequency of isolated pelvic DVT is considered uncommon, being as high as 4%, although most series report less than 2% (2,5,6). However, others have argued that thrombus may initially arise from the more proximal and larger vessels of the leg and pelvis (8,17,18), and that imaging studies used to confirm the absence of isolated pelvic DVT may be insensitive (19,20).

Multiple studies (4,9,21) have established the high accuracy of MR imaging in identifying DVT of the lower extremity. Carpenter et al (4) demonstrated identical results between MR venography and conventional ascending venography in 98 (97%) of 101 venous systems in 85 patients. In a prospective study involving 61 patients (64 studies), Evans et al (9) compared ascending venography with gradient-recalled-echo MR venography. In the thigh, there was complete concordance between the two modalities, whereas in the calf, the sensitivity of MR venography was 87% with a 97% specificity.

MR venography provides excellent visualization of the pelvic veins and is considered by some to be the reference standard for the evaluation of pelvic DVT (4,11,22–25). In the series reported by Evans et al (9), ascending venography and MR venography agreed in 59 of 64 cases in the pelvis. In five cases, MR venography showed the thrombus but ascending venography did not. In two of three discordant cases, direct-puncture venography enabled identification of acute thrombus. In an additional two studies, follow-up examinations with MR venography showed resolution of the perceived abnormalities following treatment. With use of direct-puncture venography as the reference standard in cases of discordance, MR venography in the pelvis was shown to be 100% sensitive and 95% specific, whereas ascending venography was 78% sensitive and 100% specific. With direct-puncture venography and follow-up MR venography as the reference standard, the sensitivity of MR venography remained 100% with a specificity of 98%, whereas the sensitivity of ascending venography decreased to 64% with a specificity of 100% (9).

Montgomery et al (25) considered MR venography to be the reference standard in assessing 45 patients with acetabular fractures. In 15 patients, MR venography enabled detection of 24 thrombi. Only 10 of these thrombi (42%) were detected with ascending venography, and nine of 10 thrombi were identified in the thigh. The authors state that the MR venographic findings changed the therapeutic management in 10 patients (22%). In a follow-up study (26), the same authors report the detection of 49 thrombi in 34 of 101 patients by using MR venography. In 49% of cases (24 of 49 thrombi), the clot was localized to the common, internal, or external iliac veins.

In the current study, acute DVT was detected in 21.7% of cases. This percentage is slightly less than the 26%–53% reported in other series in which other modalities were used (4,5,9,21). However, the percentage in our current study is similar to the 18% positive rate reported from a study at our institution in which US was used to evaluate DVT (27). The relative frequency of isolated pelvic DVT of approximately 20% in our current study is considerably higher than previously reported (1%–4%) (2,3,5,6,9,10). To some extent, this represents a selection bias in the series reviewed, as patients are often referred to our institution for MR venography if they have had prior negative or inconclusive US findings or if proximal DVT is suspected clinically. However, as the preceding discussion suggests, it is also likely that the true relative frequency of isolated pelvic DVT has been underreported due to technical deficiencies of ascending venography and duplex Doppler US. In all comparative series reported, MR venography enabled detection of as many or more intraluminal abnormalities than ascending venography. In most studies, the increased detection rate of MR venography was considered to be due to false-positive findings. However, Evans et al (9) suggest that it more likely represents false-negative ascending venographic findings.

Duplex Doppler US, due to its relatively low cost and ease of use, has been established as the method of choice for screening patients with acute DVT. Its accuracy has been established both in terms of comparative studies with ascending venography and in terms of clinical outcome (4–6,8–10,28,29). Duplex

Doppler US is less reliable in evaluation of calf veins; however, the clinical importance of pulmonary embolism from the smaller veins of the calf is unclear, but likely minimal (5). Although the risk of pulmonary emboli from the larger veins of the pelvis is considerable, previous studies have demonstrated that duplex Doppler US is unreliable in demonstrating thrombosis of the pelvic veins (6).

US has been shown to have deficiencies in posttraumatic or postsurgical populations as well. Sensitivities range from 38% to 60%, and specificities range from 92% to 97% (9,11,25,28,30–32).

In a study of 75 patients in which MR venography was compared with duplex Doppler US in the thigh, MR venography was considered to be 100% sensitive and specific, compared with a sensitivity and specificity of 76% and 98%, respectively, for US (33). In a smaller series of 21 patients in which MR venography was compared with duplex Doppler and color Doppler US, Laissy et al (10) report the sensitivity and specificity, respectively, of MR venography was 95% and 99% compared with 87% and 83% for US, with ascending venography as the reference standard; these results were not considered to be statistically significant.

Dupas et al (21) reported on 25 patients who underwent MR venography, duplex Doppler and color Doppler US (17 patients), and ascending venography (25 patients) of the pelvic and common femoral veins. MR venography was 100% sensitive and 98.3% specific, whereas US was only 90.5% sensitive and 96.7% specific. Of note, the ascending venograms were uninterpretable in nearly 10% of segments, and these areas were excluded from the calculations. In this study, color duplex US was unable to depict any internal iliac veins, including each of the eight that contained clot. Furthermore, six common iliac veins and five inferior venae cavae had thrombus at ascending venography and were not seen with US.

In the present series, there were 34 cases of isolated pelvic DVT detected with MR venography. In seven of these cases, duplex Doppler US had been performed within 24 hours prior to MR venography; all seven cases were negative for acute DVT, although in one case chronic changes in the superficial femoral vein were identified. Although these data are by no means a prospective comparison of the two modalities for assessing isolated pelvic DVT, they are consistent with the previously identified deficiencies of duplex Doppler US. We must emphasize that at our institution, direct visualization of the pelvic veins by means of duplex Doppler US is not routinely attempted in the evaluation of acute DVT, although pelvic waveform variations are assessed. As such, it is possible that duplex Doppler US directed toward the pelvis would have enabled the detection of thrombus in some of these cases.

Results of other studies also support the contention that US underreports pelvic thrombus. Cramer et al (34) reported on 16 patients with abrupt onset of brain ischemia with no demonstrable cause. In each patient, an intraarterial communication (patent foramen ovale or atrial septal defect) was identified. The duplex US study was normal in each patient. In four patients, the MR venogram was positive for acute DVT; in seven patients, findings suspicious for recent thrombus were identified with MR venography; and in the remaining five patients, MR venograms were normal.

Several limitations of our study are acknowledged and likely contributed to the high percentage of isolated pelvic DVT: (*a*) As discussed previously, selection bias contributed to the high relative frequency of isolated pelvic DVT in this series, since patients are typically referred to our institution for MR venography if proximal DVT is suspected clinically. (*b*) Diagnostic proof of acute DVT with MR venography was not possible. On the basis of our personal experience and the literature, MR venography was assumed to be the reference standard, and confirmatory studies (eg, venography with direct femoral puncture) were not obtained. (*c*) The relative frequency of isolated calf DVT was likely underreported, since the calves were not completely evaluated in the majority of cases. Although the pelvis, thigh, and popliteal regions of the calf to the trifurcation were routinely included, the entire calf was thoroughly evaluated only when identification of calf thrombus would prompt anticoagulation. As such, it is possible that there was concomitant calf and pelvic thrombus in some of the cases considered to be isolated pelvic clot. (*d*) The study was retrospective in nature, so it is impossible to ascertain what clinical presentation or which signs and symptoms, if any, would increase the yield of obtaining a positive result in the pelvis. However, other studies in which different modalities were used were unable to predict which patients had acute DVT (1,2,5). (*e*) Finally, this report is a retrospective analysis with all the deficiencies inherent in such a study.

In conclusion, the present findings suggest that the relative frequency of isolated pelvic DVT may be higher than heretofore reported.

Duplex Doppler US remains the study of choice for screening patients for the presence of DVT because of its low cost and ease of use. MR venography should be considered for those situations in which proximal thrombus is likely (ie, pelvic trauma, postsurgical cases, or cryptogenic stroke) or when proximal DVT is suspected despite a negative US study. A large, prospective study involving MR venography and duplex Doppler US needs to be performed to determine the true relative frequency of isolated pelvic DVT and the true accuracy of duplex Doppler US.

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