Suspected Upper Extremity Deep Vein Thrombosis
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Strength of Evidence
1. Joffe HV, Goldhaber SZ. Upper-extremity deep vein thrombosis. *Circulation* 2002; 106(14):1874-1880.	12	N/A	To review risk factors, diagnostic options, treatment alternatives, and prophylaxis regimens of UEDVT.	• Although aggressive multimodal treatment is generally recommended for patients with primary UEDVT, this practice should be evaluated critically with prospective clinical trials. • Preliminary studies suggest that US (without pharmacotherapy) may accelerate thrombolysis by enhancing enzymatic fibrinolysis and mechanically disrupting the thrombus. Significantly lower doses of thrombolytics may be effective when used in combination with US, thereby reducing bleeding complications. Further research is needed to evaluate the safety and efficacy of this novel treatment approach.	4
2. Weissleder H, Weissleder R. Lymphedema: evaluation of qualitative and quantitative lymphoscintigraphy in 238 patients. *Radiology* 1988; 167(3):729-735.	10	238 patients	To evaluate qualitative and quantitative lymphoscintigraphy in 128 patients with primary lymphedema, in 91 patients with secondary lymphedema, and in 19 healthy volunteers.	With qualitative interpretation alone, the diagnosis of lymphedema was established in 216/308 extremities (70.1%). Quantitative parameters derived from clearance data showed abnormal lymphatic function in all 308 extremities. Whereas qualitative lymphoscintigraphy allows the characterization of lymphatic morphology, quantitative lymphoscintigraphy is very accurate in detection of incipient lymphedema.	2
3. Abdullah BJ, Mohammad N, Sangkar JV, et al. Incidence of upper limb venous thrombosis associated with peripherally inserted central catheters (PICC). *Br J Radiol* 2005; 78(931):596-600.	3a	26 patients	To prospectively determine the incidence of venous thrombosis in the upper limbs in patients with PICC.	• No statistical correlation between the site of insertion of the PICC and the location of venous thrombosis. • No observed correlation between the occurrence of venous thrombosis with the patient's history of hypertension, hypercholesterolaemia, coronary artery disease, diabetes mellitus, cardiac insufficiency, smoking or cancer. • No statistical correlation with the size of the catheter. • PICC are associated with a significant risk of UEDVT.	3
4. Baarslag HJ, Koopman MM, Reekers JA, van Beek EJ. Diagnosis and management of deep vein thrombosis of the upper extremity: a review. *Eur Radiol* 2004; 14(7):1263-1274.	12	N/A	To review the clinical background, imaging modalities that may be employed, treatment options and outcome of patients with UEDVT.	No results reported.	4

Suspected Upper Extremity Deep Vein Thrombosis
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Strength of Evidence
5. Prandoni P, Polistena P, Bernardi E, et al. Upper-extremity deep vein thrombosis. Risk factors, diagnosis, and complications. *Arch Intern Med* 1997; 157(1):57-62.	9	58 consecutive patients	To identify the clinical and laboratory parameters associated with UEDVT, to assess the diagnostic accuracy of ultrasonographic methods for its detection, and to establish the frequency of both early and late complications.	• Central venous catheters, thrombophilic states, and a previous leg vein thrombosis were statistically significantly associated with UEDVT. • Sensitivity and specificity of compression US (96% and 93.5%, respectively) and color flow Doppler imaging (100% and 93%, respectively) were comparable and better than those of Doppler US (81% and 77%, respectively). • Objective findings suggestive of a PE were recorded in 36% of the patients with UEDVT. After a mean follow-up of 2 years, two patients with UEDVT experienced recurrent thromboembolic events, and four had post-thrombotic sequelae.	2
6. Schmittling ZC, McLafferty RB, Bohannon WT, Ramsey DE, Hodgson KJ. Characterization and probability of upper extremity deep venous thrombosis. *Ann Vasc Surg* 2004; 18(5):552-557.	13	177 upper extremities of arms	Retrospective review of patients who underwent color-flow duplex scanning for clinically suspected acute UEDVT. To characterize patient demographics, risk factors, and anatomic distribution of UEDVT to develop a probability model for diagnosis.	• Color-flow duplex scanning identified acute UEDVT in 53 (30%) of the arms examined with deep system involvement in 40 (23%). Of the upper extremities affected, the subclavian was involved in 64%, the axillary in 25%, the internal jugular in 32%, the brachial in 36%, the cephalic in 32%, and the basilic in 47%. • Use of this model can help focus clinical suspicion, improve color-flow duplex utilization, and provide timely treatment with anticoagulation.	2
7. Spencer FA, Emery C, Lessard D, Goldberg RJ. Upper extremity deep vein thrombosis: a community-based perspective. *Am J Med* 2007; 120(8):678-684.	13	483 patients 69 with UEDVT	Review medical records to examine the magnitude, risk factors, management strategies, and outcomes in a population-based investigation of patients with upper, as compared with lower, extremity DVT diagnosed in 1999.	Patients with UEDVT represent a clinically important patient population in the community setting. Risk factors, occurrence of PE, and timing and location of venous thromboembolism recurrence differ between patients with upper as compared with lower extremity DVT.	2

Suspected Upper Extremity Deep Vein Thrombosis
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Strength of Evidence
8. Baarslag HJ, van Beek EJ, Koopman MM, Reekers JA. Prospective study of color duplex ultrasonography compared with contrast venography in patients suspected of having deep venous thrombosis of the upper extremities. *Ann Intern Med* 2002; 136(12):865-872.	9	126 consecutive patients	Prospective study of duplex US compared with venography to determine the accuracy of duplex US for diagnosis of UEDVT.	• Sensitivity and specificity of duplex US and venography were 82% (95% CI, 70% to 93%) and 82% (CI, 72% to 92%), respectively. • Duplex US may be the method of choice for initial diagnosis of patients with suspected UEDVT. However, in patients with isolated flow abnormalities, contrast venography should be performed.	2
9. Shebel ND, Marin A. Effort thrombosis (Paget-Schroetter syndrome) in active young adults: current concepts in diagnosis and treatment. *J Vasc Nurs* 2006; 24(4):116-126.	12	N/A	To review the prevalence, differential diagnosis, diagnostic modalities and medical and surgical interventions used to treat Paget-Schroetter.	Patients presenting with possible symptoms of Paget-Schroetter syndrome should be screened with an objective diagnostic test. Venous duplex imaging can identify acute thrombosis, but venography is necessary to confirm the diagnosis of Paget-Schroetter syndrome. Catheter-directed thrombolysis should be initiated in acute DVT to reduce the clot burden, and it offers a better long-term outcome.	3
10. Knudson GJ, Wiedmeyer DA, Erickson SJ, et al. Color Doppler sonographic imaging in the assessment of upper-extremity deep venous thrombosis. *AJR* 1990; 154(2):399-403.	10	91 patients 130 extremities	To determine the accuracy of color Doppler flow imaging in the assessment of UEDVT.	Sensitivity of the Doppler studies was 78% and the specificity was 92%. Color Doppler flow imaging is an accurate, noninvasive method for the evaluation of UEDVT. Other imaging tests may be required when the color Doppler study is negative and central venous thrombosis is suspected.	2
11. Mustafa S, Stein PD, Patel KC, Otten TR, Holmes R, Silbergleit A. Upper extremity deep venous thrombosis. *Chest* 2003; 123(6):1953-1956.	13	DVT diagnosed in 65 of 44,136 patients of all ages (0.15%) [or 64 of 34,567 adult patients ≥20 years of age; 0.19%]	Retrospective review to determine the prevalence of symptomatic UEDVT and its association with symptomatic acute PE in a community teaching hospital.	Symptomatic UEDVT is not uncommon in hospitalized patients. Symptomatic PE resulting from UEDVT was not observed in these patients, all of whom were treated with anticoagulants.	2
12. Patel MC, Berman LH, Moss HA, McPherson SJ. Subclavian and internal jugular veins at Doppler US: abnormal cardiac pulsatility and respiratory phasicity as a predictor of complete central occlusion. *Radiology* 1999; 211(2):579-583.	9	21 consecutive patients	To analyze changes in venous Doppler waveforms of damped or diminished cardiac pulsatility and respiratory phasicity. US findings were compared with phlebographic findings.	US can be used to establish the presence or absence of thrombosis in the distal portion of the brachiocephalic or subclavian veins, which are inaccessible to direct insonation.	3

Suspected Upper Extremity Deep Vein Thrombosis
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Strength of Evidence
13. Ong B, Gibbs H, Catchpole I, Hetherington R, Harper J. Peripherally inserted central catheters and upper extremity deep vein thrombosis. *Australas Radiol* 2006; 50(5):451-454.	13	317 scans 115 positive for UEDVT	Retrospective study of all UEDVT duplex scans was carried out to determine the incidence and risk factors for venous thrombosis in patients with a PICC.	• Three main risk factors identified were; presence of a central line, malignancy and administration of chemotherapy. PICC were the most common central line present. • Symptomatic thrombosis occurred in 7% of PICC inserted for chemotherapy compared with 1% of PICC inserted for other reasons.	3
14. Agarwal AK, Patel BM, Haddad NJ. Central vein stenosis: a nephrologist's perspective. *Semin Dial* 2007; 20(1):53-62.	12	N/A	To review management of central vein stenosis.	Endovascular interventions are the mainstay of management of central vein stenosis. Percutaneous angioplasty and stent placement for elastic and recurring lesions can restore the functionality of the vascular access, at least temporarily.	4
15. Lam EY, Giswold ME, Moneta GL. Venous and Lymphatic Disease. In: Brunicardi FC, Andersen DK, Billiar TR, et al., eds. *Schwartz's Principles of Surgery*. 8th ed: McGraw-Hill; 2005.	15	N/A	Textbook.	N/A	N/A
16. Hingorani AP, Ascher E, Markevich N, et al. Prospective evaluation of combined upper and lower extremity DVT. *Vasc Endovascular Surg* 2006; 40(2):131-134.	13	227 patients	Prospective study to evaluate combined upper and lower extremity DVT.	211 (93%) of 227 patients had lower extremity studies; 45 of these 211 (21%) had acute lower extremity DVT by duplex examination in addition to the UEDVT. 22/211 patients had bilateral lower extremity DVT, and 8 patients were found to have chronic thrombosis of lower extremity veins. Of the patients with bilateral UEDVT, there were 3 with bilateral lower extremity acute DVT. Finally, 8 of the remaining 166 patients (5%) with originally negative lower extremity studies were found to develop a thrombosis at a later date.	2

Suspected Upper Extremity Deep Vein Thrombosis
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Strength of Evidence
17. Constans J, Salmi LR, Sevestre-Pietri MA, et al. A clinical prediction score for upper extremity deep venous thrombosis. *Thromb Haemost* 2008; 99(1):202-207.	10	Derivation sample 140 patients; 50 had confirmed UEDVT validation sample - 103 patients; 46 had UEDVT, OPTIMEV study sample 214 patients; 65 had UEDVT	To design a clinical prediction score for the diagnosis of UEDVT.	• The clinical score identified a combination of 4 items (venous material, localized pain, unilateral pitting edema and other diagnosis as plausible). One point was attributed to each item (positive for the first 3 and negative for the other diagnosis). • A score of –1 or 0 characterized low probability patients, a score of 1 identified intermediate probability patients, and a score of 2 or 3 identified patients with high probability. • Low probability score identified a prevalence of UEDVT of 12%, 9% and 13%, respectively, in the derivation, validation and OPTIMEV (multicenter study) samples. • High probability score identified a prevalence of UEDVT of 70%, 64% and 69% respectively. • Authors propose a simple score to calculate clinical probability of UEDVT. This score might be a useful test in clinical trials as well as in clinical practice.	3
18. Merminod T, Pellicciotta S, Bounameaux H. Limited usefulness of D-dimer in suspected deep vein thrombosis of the upper extremities. *Blood Coagul Fibrinolysis* 2006; 17(3):225-226.	10	52 consecutive patients	To provide preliminary data on the potential role of D-dimer testing in clinically suspected UEDVT.	• UEDVT diagnosed in 15 patients (29%). • Sensitivity and specificity of D-dimer for the presence of UEDVT, using a diagnostic cutoff value of 500 mg/l, were 100% (95% CI, 78-100) and 14% (95% CI, 4-29), respectively, resulting in PPV and NPV of 32% (95% CI, 19-47) and 100% (95% CI, 47-100), respectively. • Results suggest both a high sensitivity and a low specificity of D-dimer in clinically suspected UEDVT, casting doubt about the usefulness of the test in the diagnostic management of this condition. The usefulness of the test in subgroups of patients with suspected UEDVT should be studied in especially designed trials.	3

Suspected Upper Extremity Deep Vein Thrombosis
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Strength of Evidence
19. Di Nisio M, Van Sluis GL, Bossuyt PM, Buller HR, Porreca E, Rutjes AW. Accuracy of diagnostic tests for clinically suspected upper extremity deep vein thrombosis: a systematic review. *J Thromb Haemost* 2010; 8(4):684-692.	11	17 articles with 793 patients 2 independent reviewers	Systematic review was performed to assess whether the diagnostic accuracy of other tests for clinically suspected UEDVT is high enough to justify their use in clinical practice and to evaluate if any test can replace venography.	• Sensitivity (95% CI) was 97% (90%-100%) for compression US, 84% (72%-97%) for Doppler US, 91% (85%-97%) for Doppler US with compression, and 85% (72%-99%) for phleboreography. The corresponding summary estimates of specificity were, respectively, 96% (87%-100%), 94% (86%-100%), 93% (80%-100%), and 87% (71%-100%). • Clinical findings, a clinical score, D-dimer, MRI, rheography and plethysmography were evaluated in one study each, involving a median number of 46 patients (range 21-214). Sensitivity and specificity ranged from 0% to 100% and from 14% to 100%. • Methodological limitations, large between-study differences and small sample sizes limit the evidence of tests for clinically suspected UEDVT. Compression US may be an acceptable alternative to venography. The addition of (color) Doppler does not seem to improve the accuracy. Adequately designed studies are warranted to confirm these findings.	3
20. Sharif-Kashani B, Behzadnia N, Shahabi P, Sadr M. Screening for deep vein thrombosis in asymptomatic high-risk patients: a comparison between digital photoplethysmography and venous ultrasonography. *Angiology* 2009; 60(3):301-307.	9	337 limbs in 169 patients	Prospective study to determine the role of digital photoplethysmography in screening asymptomatic patients who are susceptible for developing DVT. Patients at high risk for development of DVT were assessed by US digital photoplethysmography and the results were compared.	• 13 limbs were found to have DVT as demonstrated by US. All limbs with a venous refilling time greater than 12 seconds had a normal US. • Compared with US and using refilling time less than 12 seconds as the cutoff point, digital photoplethysmography achieved a sensitivity, specificity, PPV, and NPV of 100%, 73.8%, 13.3%, and 100% respectively, for detecting DVT in asymptomatic high-risk patients. • Digital photoplethysmography is a simple, noninvasive, and highly sensitive test for screening of DVT.	2

Suspected Upper Extremity Deep Vein Thrombosis
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Strength of Evidence
21. Do B, Mari C, Biswal S, Kalinyak J, Quon A, Gambhir SS. Diagnosis of aseptic deep venous thrombosis of the upper extremity in a cancer patient using fluorine-18 fluorodeoxyglucose positron emission tomography/computerized tomography (FDG PET/CT). *Ann Nucl Med* 2006; 20(2):151-155.	14	1 patient	To describe a patient with a history of recurrent squamous cell carcinoma of the tongue and abnormal FDG uptake in the left arm during a re-staging FDG-PET/CT.	After revision of the patient's clinical history, tests and physical examination, the abnormal FDG uptake was found to correspond to an extensive aseptic UEDVT.	4
22. Gloviczki P, Calcagno D, Schirger A, et al. Noninvasive evaluation of the swollen extremity: experiences with 190 lymphoscintigraphic examinations. *J Vasc Surg* 1989; 9(5):683-689; discussion 690.	10	115 patients 190 extremities	Lymphoscintigraphy performed with Tc-99m labeled antimony trisulfide colloid was used as a noninvasive diagnostic examination to evaluate the lymphatic circulation in extremities.	• Semiquantitative evaluation of the lymphatic drainage and visual interpretation of the image patterns were reliable to differentiate lymphedema from edemas of other origin (sensitivity: 92%, specificity: 100%). • Lymphoscintigraphy is safe and reliable and has no side effects. It should replace contrast lymphangiography in the routine evaluation of the swollen extremity.	2
23. Wang YF, Cherng SC, Chiu JS, Su YC, Sheu YT. Application of upper extremity radionuclide venography as a diagnostic approach for Port-A catheter thrombosis. *J Chin Med Assoc* 2006; 69(8):358-363.	10	14 symptomatic patients	To investigate the role of upper extremity radionuclide venography as a potential diagnostic modality in the assessment of venous thrombosis associated with a Port-A catheter.	Upper extremity radionuclide venography is an easily performed and effective method for diagnosing Port-A catheter thrombosis in clinical practice.	3
24. Baxter GM, Kincaid W, Jeffrey RF, Millar GM, Porteous C, Morley P. Comparison of colour Doppler ultrasound with venography in the diagnosis of axillary and subclavian vein thrombosis. *Br J Radiol* 1991; 64(765):777-781.	9	66 patients	Prospective study to compare bilateral venography with US for detection of DVT in the upper venous system in children with acute lymphoblastic leukemia.	• DVT occurred in 29% (19/66) patients. • While 15/19 DVT were detected by venography (sensitivity 79%), only 7/19 were detected by US (sensitivity 37%). • US is insensitive for DVT in the central upper venous system but may be more sensitive than venography in the jugular veins. A combination of both venography and US is required for screening for DVT in the upper venous system.	2

Suspected Upper Extremity Deep Vein Thrombosis
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Strength of Evidence
25. Koksoy C, Kuzu A, Kutlay J, Erden I, Ozcan H, Ergin K. The diagnostic value of colour Doppler ultrasound in central venous catheter related thrombosis. *Clin Radiol* 1995; 50(10):687-689.	9	44 patients	Prospective study to establish the correlation between color Doppler US observations and venography in detecting catheter-related thrombosis. Criteria used to show the presence of catheter-related thrombosis included visualization of thrombus, absence of spontaneous flow, absence of phasicity of flow with respiration, incompressibility of the vein with probe pressure and visualization of increased venous collaterals.	Analyzing each variable separately, phasicity of flow with respiration had the highest sensitivity (94%) and spontaneous flow had the highest specificity (100%). The best combinations for diagnosis were visualization of thrombus + phasicity of flow with respiration, phasicity of flow with respiration + spontaneous flow, and visualization of thrombus + phasicity of flow with respiration + spontaneous flow with a sensitivity of 94% and specificity of 88%. Overall diagnostic value of color Doppler US had a sensitivity of 94% and specificity of 96%.	2
26. Weissleder R, Elizondo G, Stark DD. Sonographic diagnosis of subclavian and internal jugular vein thrombosis. *J Ultrasound Med* 1987; 6(10):577-587.	14	7 patients	Patients with internal jugular and/or subclavian vein thrombosis were studied with real-time US and venography. High-resolution real-time US was used to tabulate morphologic parameters and physiologic parameters.	Two new signs of thrombosis, the absence of the beating venous valve and the "cut-off sign," are particularly useful in the US diagnosis of internal jugular vein thrombosis.	4
27. Chin EE, Zimmerman PT, Grant EG. Sonographic evaluation of upper extremity deep venous thrombosis. *J Ultrasound Med* 2005; 24(6):829-838; quiz 839-840.	13	N/A	To review the techniques of performing an upper extremity Doppler examination, in addition to illustrating the sonographic appearances of acute and chronic UEDVT.	Color Doppler US is accurate in the diagnosis of UEDVT. However, in cases of equivocal Doppler findings, or when the sonographic findings are normal but clinical suspicion for central venous thrombosis is high, MRI or contrast venography is necessary for further evaluation.	3
28. Haire WD, Lynch TG, Lund GB, Lieberman RP, Edney JA. Limitations of magnetic resonance imaging and ultrasound-directed (duplex) scanning in the diagnosis of subclavian vein thrombosis. *J Vasc Surg* 1991; 13(3):391-397.	9	43 arm phlebograms	Correlate the results of phlebograms with duplex and MRI scans of the thoracic veins to determine the potential role of MRI and duplex scanning in the diagnosis of catheter-induced subclavian vein thrombosis.	• Duplex scans detected 6/11 occlusions, whereas MRI detected 4 of the 5 occlusions scanned. • Of 14 nonocclusive thrombi seen on phlebography, duplex scans correctly identified 8. • MRI was done on 8 nonocclusive thrombi but identified only 2. • Short occlusions of the proximal portion of the left subclavian vein were often undetected by duplex scanning but occasionally seen with MRI. • MRI is highly reliable in ruling out the presence of a thrombotic process in the subclavian vein, but it may on occasion fail to detect the presence of subclavian thrombi.	3

Suspected Upper Extremity Deep Vein Thrombosis
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Strength of Evidence
29. Svensson WE, Mortimer PS, Tohno E, Cosgrove DO. Colour Doppler demonstrates venous flow abnormalities in breast cancer patients with chronic arm swelling. *Eur J Cancer* 1994; 30A(5):657-660.	10	81 patients	Patients with chronic arm swelling related to their breast cancer treatment were examined with color Doppler imaging. Findings are reported.	Over half (57%) of the patients had evidence of venous outflow obstruction and a further 14% had signs of venous "congestion". Only 30% of the swollen arms had normal venous outflow. The venous systems of the contralateral non-swollen arms were all normal as were both arms in 28 control patients who had similar treatment but had not developed arm swelling. Findings suggest that venous outflow obstruction is an important contributory factor in the pathophysiology of arm swelling following breast cancer treatment.	2
30. Weber TM, Lockhart ME, Robbin ML. Upper extremity venous Doppler ultrasound. *Radiol Clin North Am* 2007; 45(3):513-524.	12	N/A	To review the role of US in the evaluation of UEDVT.	US provides an accurate, rapid, low-cost, portable, noninvasive method for screening, mapping, and surveillance of the UEDVT system.	4
31. Grassi CJ, Polak JF. Axillary and subclavian venous thrombosis: follow-up evaluation with color Doppler flow US and venography. *Radiology* 1990; 175(3):651-654.	9	13 patients	Real-time US and color Doppler flow mapping were used to determine prospectively whether UEDVT could be imaged as accurately as with conventional contrast venography.	Color Doppler flow US is useful in evaluating UEDVT and might be preferable to venography for follow-up because the discomfort of injection and risk of contrast material-induced phlebitis are eliminated.	3
32. Gaitini D, Beck-Razi N, Haim N, Brenner B. Prevalence of upper extremity deep venous thrombosis diagnosed by color Doppler duplex sonography in cancer patients with central venous catheters. *J Ultrasound Med* 2006; 25(10):1297-1303.	12	N/A	To review the literature concerning UEDVT diagnosed by color Doppler duplex US in cancer patients with indwelling central venous catheters.	Color Doppler duplex US is an accurate examination for the diagnosis of UEDVT, with sensitivity ranging from 78% to 100% and specificity ranging from 82% to 100%.	3
33. Haire WD, Lynch TG, Lieberman RP, Lund GB, Edney JA. Utility of duplex ultrasound in the diagnosis of asymptomatic catheter-induced subclavian vein thrombosis. *J Ultrasound Med* 1991; 10(9):493-496.	10	32 subclavian catheters	Prospective study to determine the usefulness of duplex US in the diagnosis of asymptomatic catheter-induced subclavian vein thrombosis.	16 arm venograms were normal and all gave normal duplex scans. 11 venograms demonstrated nonocclusive mural thrombi. Only 3 of these were seen with duplex US. Five totally occlusive thrombi were seen on venography, of which only 2 were detected with duplex US. The insensitivity of this technique to asymptomatic subclavian thrombi limits its usefulness as a screening tool.	3
34. Ho VB, Corse WR, Hood MD, Rowedder AM. Magnetic resonance angiography of the thoracic vessels. *Magnetic Resonance Imaging Clinics of North America* 2004; 12(4):727-747.	12	N/A	To review MR techniques used in the evaluation of the thoracic vessels.	Most thoracic vascular lesions can be well evaluated if the appropriate combination of pulse sequences is performed.	4

Suspected Upper Extremity Deep Vein Thrombosis
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Strength of Evidence
35. Hansen ME, Spritzer CE, Sostman HD. Assessing the patency of mediastinal and thoracic inlet veins: value of MR imaging. *AJR* 1990; 155(6):1177-1182.	13	31 patients	Review hospital records and MR studies to assess the accuracy of MRI in the evaluation of patients with suspected thoracic venous obstruction.	MRI correctly identified abnormality in 32/34 vessels (sensitivity 94%). In all cases, a negative MR study was found to be a true negative (no false positives in 42 normal vessels; specificity, 100%).	2
36. Blume U, Orbell J, Waltham M, Smith A, Razavi R, Schaeffter T. 3D T(1)-mapping for the characterization of deep vein thrombosis. *MAGMA* 2009; 22(6):375-383.	10	Phantoms and 8 healthy volunteers 5 patients with DVT	To investigate fast T (1)-mapping for the characterization of DVT. Accuracy and reproducibility of the T (1)-mapping sequence was tested in phantoms and in healthy volunteers on a 1.5 T clinical scanner using a 32-channel array coil.	• Results of phantom and volunteer study showed a high accuracy and reproducibility for the quantification of T (1). The resolution of the T (1)-maps was high enough to identify small anatomical structures. • T (1) values derived for normal blood and various other tissues were comparable to those reported in the literature. • In all patients, the T (1) times of thrombi showed decreased values (T (1) = 843 +/- 91 ms) in the acute phase and recovered back to normal values of blood (T (1) = 1,317 +/- 36 ms) after 6 months. • Measurement of all relevant T (1) values of acute thrombi and normal blood achieved accurate and reproducible results in vivo. Fast T (1) quantification of the thrombus can provide information about tissue characteristics such as thrombus resolution. Such a quantitative MRI technique may be valuable in studying the factors that influence natural resolution and in evaluating treatment effects that enhance this process.	3
37. Baarslag HJ, Van Beek EJ, Reekers JA. Magnetic resonance venography in consecutive patients with suspected deep vein thrombosis of the upper extremity: initial experience. *Acta Radiol* 2004; 45(1):38-43.	9	44 patients	To assess the feasibility and accuracy of two MRV methods in a consecutive series of patients with suspected UEDVT.	• The sensitivity and specificity of time of flight MRV vs gadolinium 3D-MRV was 71% and 89% vs 50% and 80%, respectively. • A high number of patients were unable to undergo MRV in this setting. Contrast-enhanced MRV did not improve diagnostic accuracy. The clinical utility of MRV in the setting of suspected UEDVT seems disappointing.	2

Suspected Upper Extremity Deep Vein Thrombosis
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Strength of Evidence
38. Finn JP, Zisk JH, Edelman RR, et al. Central venous occlusion: MR angiography. *Radiology* 1993; 187(1):245-251.	9	30 patients	To evaluate time-of-flight MRA in patients with suspected thoracic venous occlusion by comparing MR studies with contrast venography results.	Correlation was excellent between findings of venous obstruction and occlusion at contrast venography and MRA. MRI provided more comprehensive information than catheter venography on central venous anatomy and blood flow. For evaluation of central veins, MRA is an accurate and graphic technique that may succeed in cases in which other methods may give inadequate findings or may be impossible to perform.	3
39. Vogt FM, Herborn CU, Goyen M. MR venography. *Magn Reson Imaging Clin N Am* 2005; 13(1):113-129, vi.	12	N/A	To review existing MR techniques used for the assessment of the venous system and summarize the clinical experience. New applications that are likely to increase the use of MRV in clinical practice are also reviewed.	Although MRV has successfully shown its potential to evaluate DVT, central venous pathology, and anatomic variants with high accuracy, technical limitations, high cost, limited availability, and logical constraints still prevent its widespread clinical use.	3
40. Spritzer CE. Progress in MR imaging of the venous system. *Perspect Vasc Surg Endovasc Ther* 2009; 21(2):105-116.	12	N/A	Review the utility of MRI/MRV in the assessment of common venous problems.	A brief synopsis of current MRI/MRV techniques used in the assessment of common venous problems is presented. This is followed by a review of application of these techniques to specific diagnoses. MRV is quite useful for assessing venous pathology.	4
41. Cantwell CP, Cradock A, Bruzzi J, Fitzpatrick P, Eustace S, Murray JG. MR venography with true fast imaging with steady-state precession for suspected lower-limb deep vein thrombosis. *J Vasc Interv Radiol* 2006; 17(11 Pt 1):1763-1769.	9	24 patients	Prospective study of randomly selected patients to compare true FISP MRV for suspected DVT with contrast agent-enhanced venography.	• When results were analyzed on a per-patient basis, there was good agreement between contrast venography and MRV (kappa=0.64; 95% CI, 0.33-0.94; P=.0001). • When the venous system was analyzed on a segmental basis, there was very good agreement between contrast venography and MRV (kappa=0.81; 95% CI, 0.68-0.94; P=.0001). The sensitivity and specificity for DVT detection were 100% for the iliac and popliteal segments and 100% and 98%, 68% and 94%, and 87% and 98%, respectively, for the femoral, below-knee, and all veins. • MRV with axial true FISP allows noninvasive rapid diagnosis of acute DVT in the iliac, femoral, popliteal, and calf muscle veins. MRV is much less reliable in the tibial or peroneal veins. It may demonstrate a nonvenous cause of a patient's symptoms.	2

Suspected Upper Extremity Deep Vein Thrombosis
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Strength of Evidence
42. Miyazaki M, Sugiura S, Tateishi F, Wada H, Kassai Y, Abe H. Non-contrast-enhanced MR angiography using 3D ECG-synchronized half-Fourier fast spin echo. *J Magn Reson Imaging* 2000; 12(5):776-783.	10	16 healthy volunteers	Developed a non-contrast-enhanced 3D MRA technique, which acquires images in a reasonably short scanning time and requires no contrast agent. An ECG synchronized 3D half-Fourier fast spin-echo technique with an appropriate ECG delay time for every slice encoding in 3D terms was used to examine the thoracic and iliac regions in volunteers at both 0.5 and 1.5 T.	Good-quality 3D MRA images were obtained in the thoracic and abdominal regions and the weighted subtraction of two images in different phases provides contrast enhancement between arteries and veins. Fast spin-echo may be a useful technique to evaluate peripheral arteries without the use of gadolinium.	3
43. Pedrosa I, Morrin M, Oleaga L, Baptista J, Rofsky NM. Is true FISP imaging reliable in the evaluation of venous thrombosis? *AJR* 2005; 185(6):1632-1640.	10	25 MR exams in 24 patients 2 independent reviewers	Retrospective study to evaluate the accuracy of true FISP in the diagnosis of venous thrombosis using gadolinium-enhanced 3D T1-weighted gradient-echo images and correlative imaging as the gold standard.	• Venous thrombosis was present in 25 veins in 18 patients. True FISP images had a lower sensitivity (66%) and specificity (70.9%) for the diagnosis of venous thrombosis than gadolinium-enhanced MR images ($P<0.01$). • True FISP images have lower sensitivity and specificity in the diagnosis of venous thrombosis than gadolinium-enhanced T1-weighted gradient-echo images. True FISP images should not be used exclusively for the diagnosis of venous thrombosis.	3
44. Denson K, Morgan D, Cunningham R, et al. Incidence of venous thromboembolism in patients with traumatic brain injury. *Am J Surg* 2007; 193(3):380-383; discussion 383-384.	13	5,787 patients	To review the incidence of venous thromboembolism in critically injured patients with an isolated traumatic brain injury using a standardized venous duplex color-flow Doppler imaging program and to compare it with the overall and high-risk trauma populations.	539 (9%) of 5,787 were deemed high-risk for venous thromboembolism. The incidence of venous thromboembolism in patients with isolated traumatic brain injury (88, 16%) was 25%. All patients and the high-risk population had incidences of 2% and 17%, respectively. The incidence of venous thromboembolism in isolated traumatic brain injury is greatest in patients with intraparenchymal hemorrhage. Early venous thromboembolism prophylaxis is warranted in traumatic brain injury patients.	2
45. Tanju S, Sancak T, Dusunceli E, Yagmurlu B, Erden I, Sanlidilek U. Direct contrast-enhanced 3D MR venography evaluation of upper extremity deep venous system. *Diagn Interv Radiol* 2006; 12(2):74-79.	9	19 patients	To compare MRV and conventional angiograms to determine the diagnostic value of direct contrast-enhanced 3D MRV in mapping the UEDVT and to plan potential interventional procedures.	Results of MRV and conventional angiography were consistent with each other (100% sensitivity and 100% specificity). Direct contrast-enhanced 3D MRV is a well-tolerated sensitive technique in explaining the cause of the malfunctioning arterio-venous fistulas and in pre-surgical planning before placing new catheters or creating fistulas.	3

Suspected Upper Extremity Deep Vein Thrombosis
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Strength of Evidence
46. Vymazal J, Spuentrup E, Cardenas-Molina G, et al. Thrombus imaging with fibrin-specific gadolinium-based MR contrast agent EP-2104R: results of a phase II clinical study of feasibility. *Invest Radiol* 2009; 44(11):697-704.	10	52 total patients thrombus in the venous system (n=14), or in the heart, or arterial system (n=38) EP-2104R: <1 hour (n=16), 2 to 6 hours (n=36), and/or 20 to 36 hours (n=33)	To determine the feasibility of detecting thrombi using a fibrin-specific gadolinium-based MRI contrast agent, EP-2104R. Results of phase II clinical study.	• Overall, 29 thrombi were visible before contrast administration, 3/14 in the venous system, and 26/38 in the arteries and heart. Thrombi generally enhanced in signal after EP-2104R injection, and an additional 7 were visualized. • After contrast, 4/14 thrombi were visible in the venous system, and 32/38 in the arteries and heart. • Thrombi were more conspicuous when imaged at 2 to 6 hours post EP-2104R compared with within 1 hour, because of lower blood background. • Quantitatively, the post: pre-signal intensity ratio was 1.90 at 2 to 6 hours post injection (standard deviation = 1.08, n=20, P<0.001); and 2.04 (standard deviation = 1.29, n=19, P<0.0025) for the 20 to 36 hours time point. • There were no serious adverse events considered related to study drug. • EP-2104R enhanced MRI detects thrombi not readily visible in precontrast screening and gives additional enhancement of thrombi that are visible in precontrast imaging.	2
47. Kim CY, Mirza RA, Bryant JA, et al. Central veins of the chest: evaluation with time-resolved MR angiography. *Radiology* 2008; 247(2):558-566.	10	27 consecutive patients 6 reviewers	To retrospectively assess the diagnostic performance of time-resolved MRA in the detection of stenoses and occlusions in the central veins of the chest, with angiographic and surgical findings and consensus readings serving as the reference standard.	Use of time-resolved angiographic data sets as a stand-alone technique had high sensitivity (0.95) but only moderate specificity (0.56) in the detection of venous stenoses or occlusions. Time-resolved angiographic images are a useful adjunct to high-spatial-resolution images in the evaluation of central venous stenoses and occlusions.	2
48. Ruehm S, Kroeger K, Bosk S, Massing S, Mteiescu S, Debatin J, et al. Thromboembolic disease: Assessment with whole body MR venography. *Academic Radiology* 2005; 12(5, Supplement 1):S63.	9	30 patients	To assess the diagnostic accuracy of a comprehensive MR protocol comprising MRA of the pulmonary arteries and whole body MRV for the detection of thromboembolic disease.	For the detection of venous thrombosis, MRV showed an overall sensitivity and specificity of 95% and 93%, respectively.	2

Suspected Upper Extremity Deep Vein Thrombosis
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Strength of Evidence
49. Nael K, Krishnam M, Ruehm SG, Michaely HJ, Laub G, Finn JP. Time-resolved MR angiography in the evaluation of central thoracic venous occlusive disease. *AJR* 2009; 192(6):1731-1738.	9	20 consecutive patients 2 independent reviewers	Retrospective study to assess the feasibility and diagnostic performance of time-resolved MRA in the evaluation of central thoracic venous occlusive disease and to compare time-resolved MRA with conventional MRA and catheter angiography. Observers were blinded to demographic information and other correlative imaging findings.	• Time-resolved MRA resulted in diagnostic-quality images that did not differ significantly in quality compared with conventional MRA. • 31 segmental venous stenoses were identified. The kappa coefficient revealed moderate intermodality agreement (kappa = 0.54; 95% CI, 0.32-0.76) between time-resolved MRA and conventional MRA. • When compared with catheter angiography, the sensitivity and specificity for the diagnosis of significant stenosis (≥70%) were 87.5% and 68% for time-resolved MRA and 90% and 90% for conventional MRA, respectively. • Time-resolved MRA has the potential to be used as an initial and screening diagnostic tool obviating conventional MRA and its associated higher contrast dose in normal and near-normal examinations. However, because of its relatively lower specificity, adjunct use of conventional MRA is still required for accurate grading of venous occlusive disease.	3
50. Sampson FC, Goodacre SW, Thomas SM, van Beek EJ. The accuracy of MRI in diagnosis of suspected deep vein thrombosis: systematic review and meta-analysis. *Eur Radiol* 2007; 17(1):175-181.	11	14 articles	Systematic review of literature and meta-analysis to estimate the diagnostic accuracy of MRI for DVT.	Pooled estimate of sensitivity was 91.5% (95% CI, 87.5%-94.5%) and the pooled estimate of specificity was 94.8% (95% CI, 92.6%-96.5%). Sensitivity for proximal DVT was higher than sensitivity for distal DVT (93.9% vs 62.1%). Individual studies reported sensitivity ranging from zero to 100%, while specificity ranged from 43% to 100%. MRI has equivalent sensitivity and specificity to US for diagnosis of DVT, but has been evaluated in many fewer studies, using a variety of different techniques.	2
51. Panzironi G, Rainaldi R, Ricci F, Casale A, De Vargas Macciucca M. Gray-scale and color Doppler findings in bilateral internal jugular vein thrombosis caused by anaplastic carcinoma of the thyroid. *J Clin Ultrasound* 2003; 31(2):111-115.	14	1 patient	To report the sonographic findings in a case of bilateral internal jugular vein thrombosis with mild symptoms.	There was evidence of direct infiltration of anaplastic thyroid carcinoma into the left internal jugular vein. Sonographic and CT examinations also demonstrated multiple dilated collateral veins.	4

Suspected Upper Extremity Deep Vein Thrombosis
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Strength of Evidence
52. Stam J. Thrombosis of the cerebral veins and sinuses. *N Engl J Med* 2005; 352(17):1791-1798.	12	N/A	To review pathogenesis of sinus thrombosis, risk factors, clinical and radiologic diagnosis and current evidence and controversies about the best treatment.	Sinus thrombosis remains a diagnostic challenge and a potentially disabling or lethal disease, but improved diagnosis and treatment now result in an excellent outcome for most patients.	4
53. Kim HC, Chung JW, Yoon CJ, et al. Collateral pathways in thoracic central venous obstruction: three-dimensional display using direct spiral computed tomography venography. *J Comput Assist Tomogr* 2004; 28(1):24-33.	10	N/A	To illustrate the spectrum of venous collateral pathways caused by the thoracic central venous obstruction with direct spiral CT venography and 3D reconstruction images.	Venous structures that can be demonstrated with CT venography include the jugular veins; the subclavian and brachiocephalic (innominate) veins; the internal and lateral thoracic veins; the superior and inferior venae cavae; the pericardiophrenic veins; the azygos, hemiazygos, and accessory hemiazygos veins; and the intercostal veins.	4
54. Sabharwal R, Boshell D, Vladica P. Multidetector spiral CT venography in the diagnosis of upper extremity deep venous thrombosis. *Australas Radiol* 2007; 51 Suppl:B253-256.	14	1 patient	To present a case which demonstrates the limitations in diagnostic accuracy of US in the diagnosis of UEDVT.	Multidetector spiral CT continues to evolve as a state of the art imaging modality and this case demonstrates the role and value of multidetector spiral CT venography in the diagnosis of UEDVT.	4
55. Kim H, Chung JW, Park JH, et al. Role of CT venography in the diagnosis and treatment of benign thoracic central venous obstruction. *Korean J Radiol* 2003; 4(3):146-152.	9	18 patients 2 observers	Prospective study. CT venography and digital subtraction venography were compared to evaluate the role of CT venography in the diagnosis and treatment of benign thoracic central venous obstruction.	The findings of CT venography correlated closely with those of digital subtraction venography. CT venography accurately depicted the degree and extent of benign venous obstruction.	3
56. Arrive L, Crema MD, Lewin M, et al. Computed tomography features of acute thrombosis of central veins with perivenous inflammatory changes. *J Comput Assist Tomogr* 2007; 31(6):931-935.	10	13 patients with acute DVT of 21 central veins	Retrospective study. To examine the CT findings in patients with acute DVT of central veins of the neck, chest, and abdomen in whom major perivenous inflammatory changes were noted.	• The perivenous changes took the form of a rounded or lobulated perivenous bulky mass (massive pattern or tumor like) in 5 patients and of infiltrative changes in the other 8 patients. • Direct visualization of the thrombotic vein was possible in 8 patients. • Follow-up examinations (range, 6-36 months; mean, 15 months) demonstrated resolution of perivenous inflammatory changes with anticoagulation therapy in all cases. • Perivenous inflammatory changes around the thrombotic vein presented as a rounded or lobulated perivenous bulky mass that may mimic a tumor or as infiltrative perivenous changes.	3

Suspected Upper Extremity Deep Vein Thrombosis
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Strength of Evidence
57. New CT Protocol Yields Improved Venous Images. *RSNA News* 2008; 18(1):6-7.	12	N/A	To review a new CT protocol in the diagnosis of venous diseases.	Two researchers, through a trial and error method, have found that changing the contrast bolusing and acquisition timing in multidetector CT of the chest satisfies the demand of thoracic and vascular surgeons for reliable venous images and may also increase reliability in the diagnosis of venous diseases.	3
58. American College of Radiology. *Manual on Contrast Media*. Available at: http://www.acr.org/SecondaryMainMenuCategories/quality_safety/contrast_manual.aspx.	15	N/A	Guidance document on contrast media to assist radiologists in recognizing and managing risks associated with the use of contrast media.	N/A	3

Evidence Table Key

Study Type Key

Numbers 1-7 are for studies of therapies while numbers 8-15 are used to describe studies of diagnostics.

1. Randomized Controlled Trial — Treatment
2. Controlled Trial
3. Observation Study
    a. Cohort
    b. Cross-sectional
    c. Case-control
4. Clinical Series
5. Case reviews
6. Anecdotes
7. Reviews
8. Randomized Controlled Trial — Diagnostic
9. Comparative Assessment
10. Clinical Assessment
11. Quantitative Review
12. Qualitative Review
13. Descriptive Study
14. Case Report
15. Other (Described in text)

Strength of Evidence Key

- Category 1 - The conclusions of the study are valid and strongly supported by study design, analysis and results.
- Category 2 - The conclusions of the study are likely valid, but study design does not permit certainty.
- Category 3 - The conclusions of the study may be valid but the evidence supporting the conclusions is inconclusive or equivocal.
- Category 4 - The conclusions of the study may not be valid because the evidence may not be reliable given the study design or analysis.

Abbreviations Key

CI = Confidence interval

CT = Computed tomography

ECG = Electrocardiogram

FDG-PET = Fluorine-18-2-fluoro-2-deoxy-D-glucose-positron emission tomography

FISP = Fast imaging with steady-state precession

DVT = Deep venous thrombosis

MRA = Magnetic resonance angiography

MRI = Magnetic resonance imaging

MRV = Magnetic resonance venography

NPV = Negative predictive value

PE = Pulmonary embolism

PICC = Peripherally inserted central catheters

PPV = Positive predictive value

UEDVT = Upper extremity deep vein thrombosis

US = Ultrasound