Learning objectives

Ultrasound Doppler is a reliable method for examining the upper extremity (UE) venous system, particularly for diagnose deep vein thrombosis (DVT) in symptomatic patients with recognizable risk factors.

It is a noninvasive technique with high sensivity and specificity in diagnosis of jugular, distal subclavian and axillary deep vein thrombosis (UEDVT).

The authors propose to attend these objectives:

• To understand the importance of a systematic and proper technique to accurately diagnose an UEDVT;
• To review ultrasound, ultrasound-color and ultrasound-spectral Doppler findings that radiologist should be familiarized when performing an UE venous examination.
Background

CLINICAL PERSPECTIVES

UEDVT is an increasingly important clinical entity with potential for considerable morbidity, which incidence is increasing paralleling the increased use of central venous catheters. UEDVT has been reported in up to one fourth of patients with these catheters. Pulmonary embolism is present in up to one third of patients affected.

For these reasons, it is imperative that radiologists recognize UEDVT risk factors (Table 1 on page 16) understanding it clinical presentation.

UEDVT is classified as primary or secondary on the basis of pathogenesis.

Primary UEDVT

Primary UEDVT is a rare disorder that refers either to Paget-Schroetter Syndrome, thoracic outlet obstruction or idiopathic UEDVT.

- **Paget-Schroetter Syndrome:**

  It refers to development of spontaneous UEDVT, usually in dominant arm of an otherwise healthy and young patient, after strenuous activity. The heavy exertion causes microtrauma to the vessel intima and leads to activation of the coagulation cascade. Significant thrombosis may occur with repeated insults to the vein wall, especially if mechanical compression of the vessel is also present.

- **Thoracic outlet obstruction:**

  It refers to compression of the neurovascular bundle (brachial plexus, subclavian artery and subclavian vein) as it exits the thoracic inlet. Compression of the subclavian vein typically develops in young athletes with hypertrophied muscles who do heavy lifting or completely abduct their arms. Cervical ribs, long transverse processes of the cervical spine, musculofascial bands, and clavicular or first rib anomalies are sometimes found in these patients.

- **Idiopathic UEDVT:**

  These patients have no known trigger or obvious underlying disease. However UEDVT may be sometimes associated with occult cancer or with hypercoagulable states. Screening for coagulation disorders should be performed in these patients, since the yield of these tests is highest for patients presenting with idiopathic UEDVT. For instance,
elevated antiphospholipid antibodies in the presence of UEDVT establish the diagnosis of the antiphospholipid antibody syndrome.

**Secondary UEDVT**

Secondary UEDVT accounts for most cases of UEDVT and develops in patients with central venous catheters, pacemakers or cancer.

- **Catheter-related thrombosis:**

  It is caused by several factors. The vessel wall may be damaged during catheter insertion or during infusion of medication. Also, the catheter may impede blood flow through the vein and cause areas of stasis. Patients with incorrectly placed catheters are more likely to develop deep vein thrombosis. Blood flow is most rapid in the SVC, which may sufficiently dilute the infusate and reduce the risk of thrombophlebitis. Therefore, catheter tips should be positioned in the lower third of this vessel or at the junction of the superior vena cava and right atrium.

**Presenting symptoms and signs**

Axillary or subclavian vein thrombosis may occasionally be completely asymptomatic. More often, patients complain of vague shoulder or neck discomfort and arm edema.

When thrombosis causes obstruction of the superior vena cava, the patient may complain of arm and facial edema, head fullness, blurred vision, vertigo or dyspnea.

Patients with thoracic outlet obstruction may have pain that radiates into the fourth and fifth digits via the medial arm and forearm, attributable to injury of the brachial plexus.

Symptoms may be position dependent and worsen with hyperabduction of the shoulder or lifting.

If thoracic outlet syndrome is suspected, the examiner should palpate the supraclavicular fossa for brachial plexus tenderness, inspect the hand and arm for atrophy, and perform provocative tests, such as Adson's and Wright's maneuvers.

Physical examination may reveal multiple signs attributable to thrombosis. However, the signs and symptoms of UEDVT are non-specific and may occur in patients with lymphedema, neoplastic compression of the blood vessels, muscle injury, or superficial vein thrombosis.

Fewer than half of these symptomatic patients will have imaging evidence of an UEDVT. Therefore, it is important to confirm or exclude the diagnosis with an imaging test.
UPPER EXTREMITY VENOUS ANATOMY

The venous system of the UE is divided into deep and superficial vessels. The distal deep veins are paired and accompany the arteries: radial and ulnar.

More proximally the venous system continues as the brachial, axillary, subclavian, and brachiocephalic veins (Fig. 1 on page 17).

Fig. 1: Schematic drawing demonstrating venous anatomy of the upper extremity.

The proximal extent of vein pairing is variable. Although the majority of patients have single brachial veins, pairing can be seen involving the axillary veins.

Communication among the veins of the deep system is also variable.

Two main veins constitute the superficial venous system of the upper extremity: the cephalic vein, along the lateral aspect of the arm, and the basilic vein along the medial side. These veins communicate at the antecubital fossa via the median antecubital vein.

The basilic vein pierces the deep fascia on the medial aspect of the mid-upper arm to merge with the brachial vein, and this combined channel becomes the axillary vein as it enters the axilla.

The cephalic vein passes more cephalad along the lateral aspect of the biceps. At the level of pectoralis major, it courses medially and deeply to pierce the clavipectoral fascia below the clavicle, and joins the axillary vein. Other tributaries from the region of the shoulder joint and the lateral chest wall drain into the axillary vein. As it crosses the first rib, the axillary vein becomes the subclavian vein.

The main tributary of the subclavian vein is the external jugular vein. The subclavian vein unites with the internal jugular vein behind the medial aspect of the clavicle to form the brachiocephalic vein, also known as the innominate vein.

The right and left brachiocephalic veins merge to form the superior vena cava, which subsequently enters the right atrium.

Perforating veins form important pathways of collateralization in the presence of partial thrombosis. In the absence of thrombus they are typically too small to see, but become more pronounced when they are recruited to divert flow around a clot.

Valves are present within the veins of the UE. As one moves peripherally the location of the first valve is quite variable, but typically is encountered in the proximal brachial vein.

**TECHNICAL PROCEDURES**

The ultrasound examination of the UE veins for diagnose DVT relies on similar principles to examination of lower extremity venous examination: gray scale compression, color Doppler and spectral Doppler.

The study is typically performed with the patient in the supine position and the arm in a neutral anatomic position. The arm should be partially abducted to examine the axillary vein.

A linear transducer is used to perform the study. Seven to 12 MHz is a good frequency range to begin the study, particularly in large or edematous arms. A higher-frequency
transducer may be used for superficial veins or in thinner arms. On the other hand, a lower-frequency transducer should be used in obese and extreme edematous arms.

1. Ultrasound and Compression

The lumen of a normal vein is anechoic. Therefore, thrombus can be directly visualized as an echogenic material affixed to the vessel wall. Fresh thrombus may be extremely hypoechoic difficulting its visualization and, therefore, is essential to perform venous compression in a transverse plane to rule out the presence of UEDVT.

Normal UE veins are easily compressible and transducer pressure will obliterate their lumens. Compression should be light because fresh clots are soft and firm pressure may give a false impression of patency.

Since the compression techniques cannot be used in portions of subclavian vein and in the inominate vein because of the overlying structures, there is a greater reliance on color-Doppler and spectral-Doppler assessment to rule out an obstruction.

2. Ultrasound Color-Doppler

Color Doppler is a useful adjunct to confirm venous patency. The entire lumen should fill with color. As a result of right atrial contraction (a-wave), it is a normal finding to observe pushes back on venous return in the larger central veins, resulting in a temporary reversal of flow. The color Doppler signal will fluctuates in direction.

It is also important also to ensure that the Doppler settings are tuned for the slower velocities found in veins. With the pulse repetition frequency adjusted to a higher level, the wall filter may suppress perception of slower laminar flow along the wall, appearance that can be confusing, mimicking a clot adherent to the wall.

On the other hand, in the larger veins with the color-Doppler pulse repetition frequency set relatively low, with a brisk augment, aliasing may occur. Both findings should be recognized as Doppler artifacts.

3. Ultrasound Spectral-Doppler

The spectral-Doppler flow profile can be used to great diagnostic advantage. A group of parameters may be analysed:
If there is no thrombus occluding the vein, the examiner will detect color spontaneously saturating all lumen of the vessel.

Because the veins of the UE are in close proximity to the heart, it is normal to see a cardiac pulsatility in the spectral analysis. Spectral analysis of the caudal internal jugular vein and the medial subclavian vein demonstrate central venous transmitted cardiac pulsatility with a, c, v peaks, and x and y descents. The presence of this pulsatility proves the patency of the conduit between the point of Doppler interrogation and the right atrium.

In addition, the examiner should identify the respiratory phasicity superimposed on cardiac pulsatility. This can be differentiated from cardiac pulsatility by observing directly a patient’s respiratory cycles. In contrast to the lower extremity veins, the velocity of blood flow in the veins of the upper extremity increases during inspiration due to negative intrathoracic pressure and increased venous return toward the heart.

Changes in these parameters may indicate central vein stenosis or occlusion.

Spectral findings of the medial and lateral aspect of the subclavian vein should be also compared because a change in the tracings may be due to stenosis in its midportion.

- **Augmentation:**
Normal venous flow is slow. Its perception on Doppler can be enhanced applying manual compression, distally to the point of assessment. In a normal venous system there will be a rapid rise and fall in the frequency shift, whereas if there is a thrombosed venous segment it will resist flow with damping or absence of the augmentation response. The squeeze should be rapid and not excessive, as there is a small potential risk of dislodging a fresh friable thrombus.

With slow flow or poorly distended veins, one can also enhance the perception of the color signal by asking the patient to perform a Valsalva maneuver. The resultant increased intrathoracic pressure resists venous return and allows more blood to pool peripherally.

Finally, respiratory phasicity and cardiac pulsatility can also be modified by asking the patients to breathe deeply and then hold their breath.

**CRITERIA OF UEDVT**

Criteria for diagnose UEDVT are similar to those used in the lower extremity. One should differentiate between a normal examination, a non-obstructive or partial UEDVT and obstructive UEDVT, as listened above:

<table>
<thead>
<tr>
<th>Interpretation</th>
<th>Gray scale compression</th>
<th>Color Doppler</th>
<th>Spectral Doppler</th>
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<tbody>
<tr>
<td>Normal</td>
<td>No intraluminal echoes</td>
<td>Color fills the lumen</td>
<td>Low velocity and phasic blood flow that augments with distal compression</td>
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<td></td>
<td>Vein compresses</td>
<td>Phasic pattern</td>
<td>Upper extremity central veins: phasic and pulsatile</td>
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*Table 4: Diagnostic criteria of upper extremity deep vein thrombosis. Normal findings. References: Instituto Português de Oncologia Francisco Gentil, EPE - Lisboa/PT*
Fig. 3: Triplex sonogram of the right subclavian vein. In addition to the rapid phasic changes in cardiac pulsatility from atrial contractions, there is a further variation in amplitude due to normal respiratory variation.

References: Instituto Português de Oncologia Francisco Gentil, EPE - Lisboa/PT

<table>
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<th>Table 5: Diagnostic Criteria of Upper Extremity Deep Vein Thrombosis</th>
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<tr>
<td><strong>Interpretation</strong></td>
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<tr>
<td>--------------------</td>
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<tr>
<td>Non occlusive UEDVT</td>
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Table 5: Diagnostic criteria of upper extremity deep vein thrombosis. Non obstructive thrombosis.

References: Instituto Português de Oncologia Francisco Gentil, EPE - Lisboa/PT

The thrombus may be directly visualized in the vessel lumen as an echogenic material affixed to the vessel wall. Fresh clots, however, will be extremely hypoechogenic dificulting their visualization.

Whenever possible, compression will help to rule out a thrombus. If there is a non obstructive clot in the lumen, the examiner will only observe a partial compression.
**Fig. 4:** Gray-scale sonogram of the left internal jugular vein (arrows) in the transverse view shows some echogenic material within it (a). Probe pressure is being exerted over the vein (b) and the thrombus is preventing the compression of the vein. This is the key to positively identifying the presence of this non-occlusive thrombus within the vein. 

**References:** Instituto Português de Oncologia Francisco Gentil, EPE - Lisboa/PT

The color Doppler will confirm the partial patency of the lumen. Cardiac periodicity and fasic respiratory variation can be present or damped according to the volume of the thrombus. Small eccentric clots may not influence these parameters. The augmentation response will be also damped.

After the release of Valsalva, absence of a surge in antegrade flow indicates a central clot. Comparison with flow dynamics on the contralateral side may be helpful in localizing the level of the clot.

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<tr>
<td>Color Doppler</td>
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<tr>
<td>Spectral Doppler</td>
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<tr>
<td><strong>Oclusive UEDVT</strong></td>
</tr>
<tr>
<td>Vein filled with intraluminal echoes (usually appears distended)</td>
</tr>
<tr>
<td>Vein does not compress</td>
</tr>
</tbody>
</table>

**Table 6:** Diagnostic criteria of upper extremity deep vein thrombosis. Obstructive thrombosis.

**References:** Instituto Português de Oncologia Francisco Gentil, EPE - Lisboa/PT
An occlusive thrombus can be visible filling the vein lumen with nonmobile echogenic material. Although fresh thrombus is relatively hypoechoic, it becomes increasingly echogenic as it matures. Fresh thrombus has a tendency to expand the vein and make it look rounder and fuller than a normal vessel, and is not particularly adherent to the vein wall.

In addition, lack of compressibility of the deep veins of the arm and neck and absence of flow on color or power Doppler are diagnostic of obstructive thrombosis.

Patent segments below the thrombus will show some slow anterograde flow, particularly if collateral channels are adequate, without any respiratory variation or cardiac pulsatility and collateral vessels may show reverse flow.

**Fig. 5:** Triplex sonogram in the longitudinal view shows an occlusive thrombus in the left axillary vein. Patent segment below the clot demonstrates some slow anterograde flow without respiratory variation or cardiac pulsatility.

**References:** Instituto Português de Oncologia Francisco Gentil, EPE - Lisboa/PT

The larger, more proximal veins, such as the axillary and subclavian, cannot be compressed, due to their location, diagnosis of thrombosis in these vessels will therefore depend on careful assessment using Doppler. Loss of respiratory phasicity or cardiac periodicity indicates proximal occlusion.
If the subclavian and jugular veins are markedly distended but Doppler reveals a flattened flow profile, an obstruction to the antegrade flow of blood and the retrograde propagation of the waveform infers the presence of a central clot:

1. If these findings are bilateral, the level of obstruction is at the superior vena cava;
2. If only one side manifests these changes, the obstructing clot is inferred to be at the level of that brachiocephalic vein.

Particularly, patients with catheter-related thrombosis, who demonstrate clots that propagate along the length of the catheter to the catheter tip, positioned within the superior vena cava, brachiocephalic or more distal veins, have a potential risk to manifest a venous return compromised. Doppler findings will reveal not only direct signs of thrombus near the portion of the catheter visualized in the subclavian vein, but also will predict the presence of a clot in non accessible vessels.

**POTENCIAL PITFALLS**

**Rouleaux**

Blood flow is anechoic because individual red blood cells are too small to reflect the incoming sound wave. However, in certain conditions as infection, diabetes mellitus or cancer, red blood cells may stick to each other, a finding that is named rouleaux. These aggregates are large enough to interact with the insonating beam, manifesting as echoes in the bloodstream, and are more likely to occur in areas of slow flow, especially in the sinus behind the cusps of valves. If compression easily dislodges these Rouleaux aggregates, presence of a clot is excluded.
Fig. 6: Gray-scale sonogram in the longitudinal view shows an area of slow flow in the right internal jugular vein mimicking deep venous thrombosis. The internal echoes were noted to swirl on real time, suggesting slow flow rather than DVT. These echoes merely represent swirling of aggregates of red blood cells large enough to interact with the insonating beam (rouleaux formation), in the setting of slow flow. Compression will confirm the complete coaptation of the vessel wall.

References: Instituto Português de Oncologia Francisco Gentil, EPE - Lisboa/PT

Arm abduction

Caution should be exercised in interpreting the distal subclavian vein, which may appear falsely narrowed as it crosses between the clavicle and the first rib at the thoracic inlet, due to complete abduction of the upper extremity during examination.

Limited acoustic window
Limited acoustic window due to bandages used to secure the catheters, radiation-induced changes on the chest wall or the presence of indwelling catheters, can make assessment of vessel compressibility challenging.

**Large venous collaterals**

In chronic obstruction, large venous collaterals often coexist and can be misinterpreted as representing patent normal vessels.

**CHRONIC CHANGES AFTER UEDVT**

**Valves**

Valve leaflets should be delicate, moving briskly with fluctuations in flow direction throughout the venous waveform, and the sinus of the valve leaflets should be relatively free of echoes. If valve cusps appear rigid or fixed, this usually represents the sequela of prior UEDVT.

**Walls**

The walls of a normal vein are smooth and non obstructive. Following recanalization after DVT they become irregular, thickened, echogenic and rarely calcified.

**Venous collaterals**

Their visualization suggests chronic thrombosis. When the normal venous channels are occluded, blood may be seen in collateral veins.

In the acute stage intramuscular channels will not have developed significantly. Increased velocity and flow may be seen.

Over a period of time the intramuscular venous channels expand and become apparent on color Doppler.

Collateral perforating veins themselves may serve as a pathway for the propagation of a clot from the superficial to the deep system. This aspect is important in the diagnosis of thrombophlebitis.
Table 1: Factors increasing risk for upper extremity deep vein thrombosis.

<table>
<thead>
<tr>
<th>Central venous catheters</th>
<th>Cancer</th>
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<tbody>
<tr>
<td>Pregnancy</td>
<td>Oral contraceptive use</td>
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<tr>
<td>Inherited thrombophilia</td>
<td>Chemotherapy</td>
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<tr>
<td>Bone marrow transplantation</td>
<td>Dialysis</td>
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<tr>
<td>Parenteral nutrition</td>
<td>Strenuous upper extremity exercise or anatomic abnormality causing venous compression</td>
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<tr>
<td>Others</td>
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Table 3: Signs of upper extremity deep vein thrombosis

<table>
<thead>
<tr>
<th>Low grade fever</th>
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<tr>
<td>Tachycardia <em>(if superior vena cava syndrome is present)</em></td>
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<td>Mild cyanosis of the involved extremity</td>
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<td>Palpable tender cord</td>
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<td>Arm and hand edema</td>
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<td>Supraclavicular fulness</td>
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<tr>
<td>Jugular venous distension</td>
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<tr>
<td>Dilated collateral veins over the chest or upper arm</td>
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<td>One or multiple ports of central venous catheter occluded</td>
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**Table 2:** Signs of upper extremity deep vein thrombosis.

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<th>Sign</th>
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<td>Asymptomatic (rare)</td>
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<tr>
<td>Vague shoulder or neck discomfort</td>
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<td>Arm edema</td>
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<tr>
<td>Facial edema, head fullness, blurred vision, vertigo or dyspnea</td>
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<td><em>(if superior vena cava syndrome is present)</em></td>
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<td>Pain radiating into the fourth and fifth digits via medial arm and</td>
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<tr>
<td>forearm <em>(if thoracic outlet obstruction is present)</em></td>
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<tr>
<td>Hand and arm atrophy <em>(if thoracic outlet obstruction is present)</em></td>
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<tr>
<td>Adson test (+)</td>
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<td>Wright test (+)</td>
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**Table 3:** Symptoms of upper extremity deep vein thrombosis.

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**Fig. 1:** Schematic drawing demonstrating venous anatomy of the upper extremity.

**Fig. 2:** Schematic image showing the spectral-Doppler findings.

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| **Table 4 Diagnostic Criteria of Upper Extremity Deep Vein Thrombosis** |
|-----------------|-----------------|-----------------|-----------------|
| **Interpretation** | **Gray scale compression** | **Color Doppler** | **Spectral Doppler** |
| **Normal**       | No intraluminal echoes | Color fills the lumen | Low velocity and phasic blood flow that augments with distal compression |
|                  | Vein compresses     | Phasic pattern    | Upper extremity central veins: phasic and pulsatile |

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**Fig. 4:** Gray-scale sonogram of the left internal jugular vein (arrows) in the transverse view shows some echogenic material within it (a). Probe pressure is being exerted over the vein (b) and the thrombus is preventing the compression of the vein. This is the key to positively identifying the presence of this non-occlusive thrombus within the vein.

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Fig. 6: Gray-scale sonogram in the longitudinal view shows an area of slow flow in the right internal jugular vein mimicking deep venous thrombosis. The internal echoes were noted to swirl on real time, suggesting slow flow rather than DVT. These echoes merely represent swirling of aggregates of red blood cells large enough to interact with the insonating beam (rouleaux formation), in the setting of slow flow. Compression will confirm the complete coaptation of the vessel wall.

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**Fig. 7:** US Doppler of a 66-year-old woman with breast cancer. Gray-scale sonogram of both internal jugular veins (arrows) in the transverse view shows complete collapse of the right vein (a), confirming the absence of thrombus in the examined segment. The left internal jugular vein shows some echogenic material within it. Note the lack of compression consistent with deep venous thrombosis (b).

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**Fig. 8:** US Doppler of a 66-year-old woman with breast cancer. Triplex sonogram in the longitudinal view shows normal changes in the right jugular vein and in the right axillary vein (c,d). Note the reduced color flow and almost absence of spectral waveform in the left internal jugular vein, consistent with thrombosis (e). Although left axillary vein shows color flow, Doppler waveform obtained reveals damping of cardiac and respiratory phasic changes (f). These are indirect findings suggesting the presence of a left brachiocephalic venous thrombus.

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**Fig. 9:** CT scan of a 66-year-old woman with breast cancer. Axial CT scan of thorax shows an asymmetric density within internal jugular veins (g), consistent with deep venous
thrombosis in the left vein. Note the presence of a central venous catheter portion in the left brachiocephalic vein, surrounded by a venous thrombus (h), confirming that Doppler findings reveal not only direct signs of thrombus in the left jugular vein, but also predict the presence of a clot in non accessible vessels.

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Fig. 10: Chest radiograph of a middle-aged women with deep venous thrombosis. Anteroposterior chest radiograph shows the central venous catheter implantation in the left subclavian vein (a). The distal tip of the catheter is in superior vena cava (arrow).

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**Fig. 11:** US Doppler of a middle-aged women with deep venous thrombosis. Triplex sonogram in the longitudinal view shows normal changes in the right jugular vein and in the right axillary vein. In the right subclavian vein color Doppler settings are at a very sensitive level. Note the color shift in the center of the vessel caused by aliasing (b,c). The left internal jugular vein shows some echogenic material, consistent with an occlusive thrombus (d). Although left axillary vein shows color flow, Doppler waveform obtained reveals damping of cardiac and of some respiratory phasic changes, suggesting the presence of a left brachiocephalic venous thrombus (e).

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**Fig. 12:** CT scan of a middle-aged women with deep venous thrombosis. Contrast-enhanced coronal CT scan of thorax shows central venous catheter implantation in the left subclavian vein. Note a clot in the left brachiocephalic vein that propagates along the length of the catheter to the catheter tip, positioned within the superior vena cava (arrows), confirming that Doppler findings reveal not only direct signs of thrombus in the left jugular vein, but also predict the presence of a clot in non accessible vessels (f,g).

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**Fig. 13:** US Doppler of a middle-aged man with inversion of flow direction in the left internal jugular vein. Gray-scale sonogram in the transverse view shows complete collapse of both internal jugular veins (arrows), confirming the absence of thrombus in these segments (a,b).

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**Fig. 14:** US Doppler of a middle-aged man with inversion of flow direction in the left internal jugular vein. Triplex sonogram in the longitudinal view shows normal changes in the right jugular vein, in the right axillary vein and in the left axillary vein (c,d,f). Note the abnormal inversion of flow direction in the left internal jugular vein and the pattern of the spectral Doppler waveform (a, c and v-waves) (e).

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**Fig. 15:** CT scan of a middle-aged man with inversion of flow direction in the left internal jugular vein. Non-enhanced and enhanced axial CT scans of thorax show a thrombus in the left brachiocephalic vein that propagates along the length of the catheter to the catheter tip, positioned within the superior vena cava (h,i,j).

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Fig. 16: US Doppler of a man with laryngeal carcinoma previously submitted to surgery. Gray-scale sonograms in the transverse and in the longitudinal view (a,b) reveal echogenic material within left internal jugular vein. On compression the walls cannot be brought together, due to the thrombus.

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Fig. 17: US Doppler of a man with laryngeal carcinoma previously submitted to surgery. Triplex sonogram in the longitudinal view shows normal spectral changes in the right axillary vein (c). Although left internal jugular vein shows color flow, Doppler waveform obtained reveals damping of cardiac and respiratory phasic changes (d) due to the presence of a clot in the caudal portion of the vein. Note the reduction of either color flow or spectral waveform in the left axillary vein (e).

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Fig. 18: CT scan of a man with laryngeal carcinoma previously submitted to surgery. Enhanced axial CT scan of thorax shows a clot that propagates along the length of
the catheter to the catheter tip positioned within the superior vena cava (arrows) and a mediastinal mass with central necrosis, evolving the left brachiocephalic vein. Note the presence of concomitant pleural metastasis and the left pleural effusion.

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Fig. 19: US Doppler of a man with deep venous thrombosis in the left internal jugular vein, complaining of vague neck discomfort. Gray-scale sonogram of both internal jugular veins (arrows) in the transverse view shows complete collapse of the right vein, confirming the absence of thrombus in the examined segment (a). The left internal jugular vein shows echogenic material within it. On compression the walls cannot be brought together, due to the thrombus (b). Gray-sonogram of the left internal jugular vein in the longitudinal view is shown (c).

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**Fig. 20:** US Doppler of a man with deep venous thrombosis in the left internal jugular vein, complaining of vague neck discomfort. Triplex sonogram in the longitudinal plane shows normal changes in the right jugular vein. Color Doppler settings are at a very sensitive level, note the color shift in the center of the vessel caused by aliasing (d). Although left internal jugular vein shows color flow, Doppler waveform obtained reveals damping of cardiac and respiratory phasic changes, because of the presence of a thrombus in the caudal portion of the vein (e).

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Fig. 21: US Doppler of a woman with diffuse large B cell lymphoma. Gray-scale sonogram of the left internal jugular vein shows echogenic material within it, due to a fresh and gelatinous thrombus that can be compressed (a,b). Note that the spectral analysis confirm the absence of a normal flow, consistent with deep venous thrombosis. (c). The US Doppler was performed after the treatment, revealing a thrombus-free lumen. The patient still alive after 5 years.

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Fig. 22: US Doppler of a women with breast cancer, using a central venous catheter for chemotherapy. Gray-scale sonogram of right internal jugular vein in the transverse view (a,b) and in the longitudinal view (c) show echogenic material within it. On compression the walls cannot be brought together, due to the clot. Triplex sonogram in the longitudinal plane demonstrates a small area of early recanalization (d). Note the absence of a spectral waveform, consistent with thrombosis (e).

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Fig. 23: US Doppler of a woman with breast cancer, using a central venous catheter for chemotherapy. Color-Doppler of right subclavian vein in the longitudinal plane shows echogenic material within it, due to a clot (f). Triplex sonogram in the longitudinal plane of right brachiocephalic vein shows absence of color flow and absence of a spectral waveform (g).

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Fig. 24: US Doppler of a woman with breast cancer, using a central venous catheter for chemotherapy. Gray-scale sonogram in the transverse view and triplex sonogram in the longitudinal plane demonstrate that the left internal jugular vein is patent. Note the presence of anterior cervical venous collaterals (h,i,j).
Fig. 25: US Doppler of a women with breast cancer, using a central venous catheter for chemotherapy. Gray-scale sonograms show catheter implantation in the left subclavian vein (l,m). Note the echogenic material and absence of flow due to a clot, observed in the triplex scan (n). The left brachiocephalic vein is patent (o).

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**Fig. 26:** US Doppler of a middle-aged man complaining of vague neck discomfort and left arm edema. Color-Doppler sonograms of the left internal jugular vein, subclavian vein and axillary vein in the longitudinal view show echogenic material within it, that appears adherent to the vessels walls, consistent with deep venous thrombosis (a,b,c) Note the heterogeneous texture of the thrombus in the left internal jugular vein, that demonstrates areas of recanalization (a).

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Fig. 27: US Doppler of a woman with a poorly differentiated carcinoma of unknown primary site. Gray-scale sonogram of an internal jugular vein in the transverse view shows echogenic material within it. On compression the walls cannot be brought together (a). Triplex scan in the longitudinal view revealed venous and arterial vascularization of a tumor thrombus infiltrating the vein lumen (b). The CT scan of the thorax revealed tumor thrombus extension until right atrium and multiple pulmonary metastasis. The patient died few months later.

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Imaging findings OR Procedure details

This Educational Exhibit presents an approach to the UE ultrasound Doppler, often performed to exclude DVT in symptomatic patients who presented in Radiology Department of our Oncologic Institution.
Conclusion

Ultrasound Doppler is the standard method for assessing the UE venous system, particularly UEDVT.

Symptomatic oncology patients, who present with a central venous catheter inserted for chemotherapy and/or develop a hypercoagulable state, are the most frequent candidates for this study.

By knowing the UE venous anatomy, expected ultrasound, ultrasound-colour Doppler findings and spectral waveforms, potential pitfalls and limitations in technique, the radiologist can generate an accurate diagnosis.
References

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