13 Imaging Assessment of Lower Limb Swelling

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13.1 Introduction

Limb swelling, known as edema, is a common clinical problem encountered in both inpatient and outpatient department. It is a challenge to determine the cause and formulate a line of treatment. A wide spectrum of causes makes it difficult for clinicians to diagnose the exact etiology; therefore, imaging can play an important role in not only determining the cause but also in image-guided interventions and follow-up after treatment. Edema is defined as a palpable swelling caused by an increase in interstitial fluid volume. In order to be specific regarding the causes, limb swelling could be unilateral or bilateral as regarding the side of affection, but regarding the onset of condition, it could be acute or chronic. In acute edema, the timing of swelling is less than 72 h and may occur in conditions like (acute DVT, cellulitis, acute compartmental syndrome, ruptured Baker's cyst, etc.), but in chronic edema the timing should exceed 72 h and usually results from chronic fluid accumulation due to systemic conditions or lymphatic obstruction [1]. There are three types of leg edema: venous edema, lymphedema, and lipedema. Venous edema consists of excess low viscosity, protein-poor interstitial fluid resulting from increased capillary filtration that cannot be accommodated by a normal lymphatic system [2]. Lymphedema consists of excess protein-rich interstitial fluid within skin and subcutaneous tissue resulting from lymphatic dysfunction [3]. Lipedema is more accurately considered a form of fat maldistribution rather than true edema [4].

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13.2 Causes

On the basis of laterality and duration of onset of edema, some important causes are listed below (Table 13.1).

13.3 Diagnostic Imaging Evaluation in Lower Limb Swelling

A multimodality imaging approach is required to overcome the clinical dilemma faced in the diagnosis of limb swelling. The main focus while imaging evaluation is to distinguish between acute DVT and its mimics. Imaging modalities to evaluate lower extremities include contrast venography, ultrasonography (B-mode and Doppler spectral analysis), MR venography, computed tomography (CT), and various radionuclide approaches (lymphoscintigraphy). A step-wise imaging work-up and keeping the anatomical spectrum of etiologies in mind while analyzing and performing different imaging techniques is a useful strategy for localizing and identifying the pathology. The examined extremity can be divided into following planes anatomically:

Table 13.1 Causes of lower leg swelling

Unilateral		Bilateral	
Acute (<72 h)	Chronic (>72 h)	Acute (<72 h)	Chronic (>72 h)
– Deep vein thrombosis	– Venous insufficiency	– Bilateral deep vein thrombosis	– Venous insufficiency
– Ruptured Baker's cyst	– Secondary lymphedema (tumor, radiation, surgery, bacterial infection)	– Acute worsening of systemic cause(heart failure, renal disease)	– Pulmonary hypertension
– Ruptured medial head of gastrocnemius	– Pelvic tumor or lymphoma causing external pressure on veins		– Heart failure
– Compartment syndrome	– Reflex sympathetic dystrophy		– Renal disease (nephrotic syndrome, glomerulonephritis)
– Acute superficial thrombophlebitis.			– Liver disease
			– Secondary lymphedema
			– Bacterial infection
			– Filariasis
			– Idiopathic edema
			– Lymphedema
			– Drugs (diuretics, etc.)
			– Premenstrual edema
			– Pregnancy

Table 13.2 Anatomical distribution of causes of lower limb swelling

1. Skin and subcutaneous tissue • Cellulitis (superficial and deep) • Closed traumatic injuries and contusions
2. Vascular system • Acute DVT • Acute superficial thrombophlebitis • Chronic venous insufficiency
3. Muscular and tendons • Injuries (hematomas, strains, tears) • Pyomyositis • Tenosynovitis • Ruptured tendons
4. Osseous and joint space related • Osteomyelitis • Fractures • Joint effusion • Septic arthritis • Baker's cyst
5. other miscellaneous causes

- Skin/subcutaneous tissues
- Vessel (mainly venous system)
- Muscles and tendons
- Joints and bones
- Other causes (systemic causes) (Table 13.2).

The key to a precise diagnosis is the definition of the imaging characteristics of various diseases that can be etiology for limb swelling.

13.4 Skin and Subcutaneous Tissue

13.4.1 Cellulitis

Cellulitis is an inflammatory condition resulting from skin or subcutaneous tissue infection usually affecting lower limbs more than upper limbs [5]. Its diagnosis is often suspected clinically and needs to be confirmed by imaging. However, imaging cannot differentiate septic from a septic fluid. **Ultrasound (US)** is an initial modality for evaluation of acute cellulitis, it is usually done first to exclude acute DVT, and then to define the ultrasound features of cellulitis which include diffusely swollen subcutaneous tissue with increased echogenicity in the affected area; further accumulation of the fluid in the subcutaneous fat gives "marbled fat appearance" or "cobble-stone appearance" (Fig. 13.1); however, this appearance is nonspecific and may exist in many other causes of edema. **Computed tomography (CT)** is particularly helpful to differentiate between the superficial (uncomplicated) type and deep

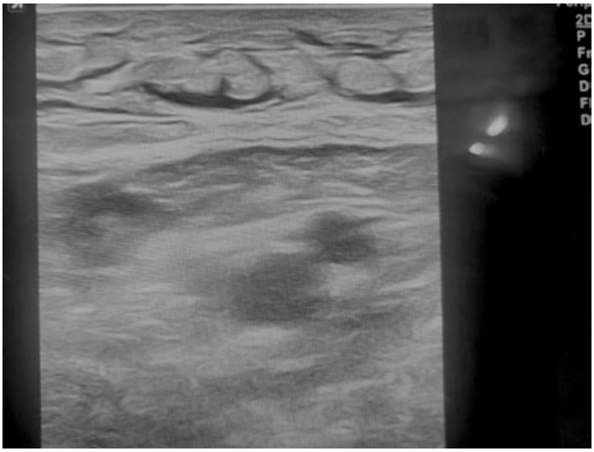


Fig. 13.1 Subcutaneous edema with cobble stoning

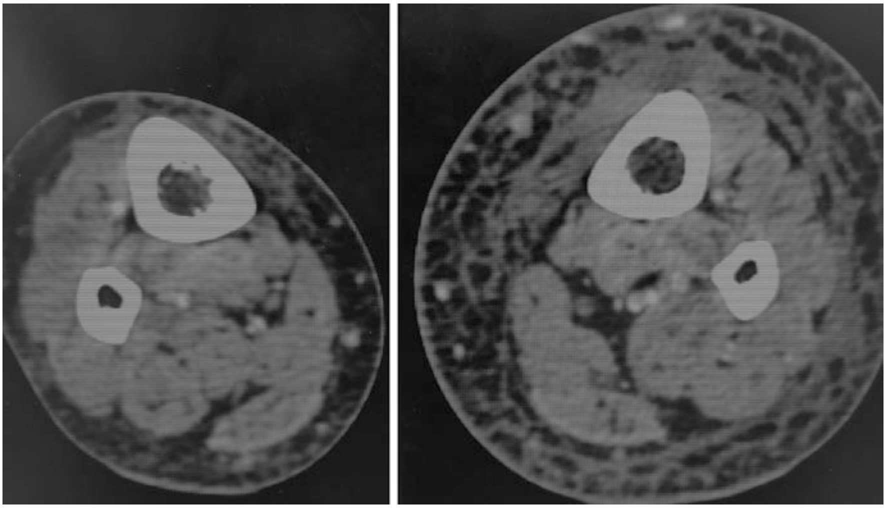


Fig. 13.2 A patient with left lower limb subcutaneous edema showing smudging and septation in subcutaneous fat

(complicated) type; the latter is usually associated with deep-seated soft tissue infections. In the superficial (uncomplicated) cellulitis, CT demonstrates thickening of the skin and superficial fascia with smudging and septation of the subcutaneous fat (Fig. 13.2). In the deep-seated cellulitis, the deep tissues are affected and may show abscess formation, myositis, and osteomyelitis, and sometimes, necrotizing fasciitis can occur caused by gas-forming pathogens with characteristic air densities that can be demonstrated in the CT examinations as well as USG (Fig. 13.3). **Magnetic resonance imaging (MRI)** in cellulitis has a nonspecific pattern similar to that of soft tissue edema; it may show thickened skin with subcutaneous fat reticulations and elicit intermediate signal intensity on T1-weighted images (T1WIs)

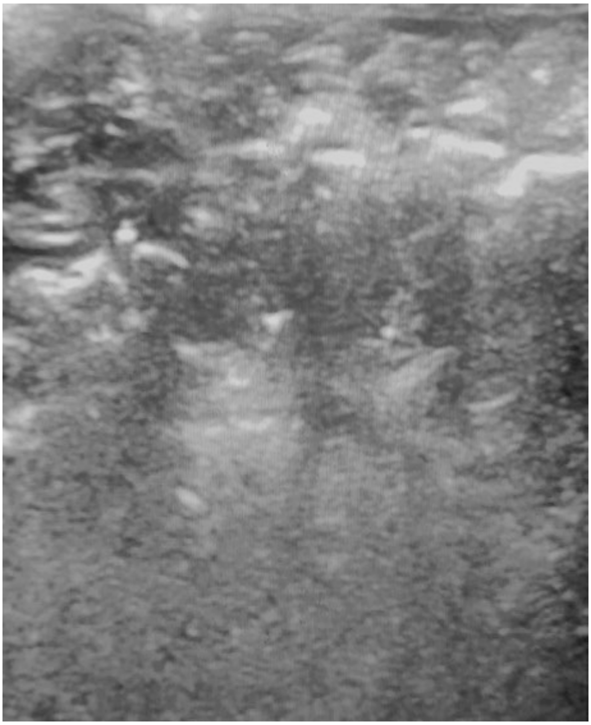


Fig. 13.3 Multiple air foci in a patient with necrotizing fasciitis

and high signal intensity on T2-weighted (T2WIs) or short tau inversion recovery (STIR) images; often the affected area has a poorly defined margin [6]. However, some differentiation can be done after contrast administration with some delay in image acquisition, where the enhancement can be detected in cellulitis but not present in nonspecific edema [7]. In some cases, associated reactive lymphadenopathy in the regional lymph nodes can be indicative of infective cause.

13.5 Vascular Disorders (Venous System)

13.5.1 Deep Venous Thrombosis

Deep venous thrombosis (DVT) is an extremely common medical problem worldwide with an estimated incidence of 120 per 100,000 person years. It is noted in both OPD and IPD, more so in patients who are sedentary. It is rarely noted in children. Some of the common predisposing factors are heart failure (prolonged), lower limb and pelvic surgeries, pregnancy, airplane travel, obesity, paraplegias, and coagulopathies [8]. The diagnosis of acute DVT is important as it may result in acute pulmonary embolism; therefore, early detection of DVT can prevent its development. Reported data suggest that in an untreated DVT, pulmonary embolism occurs in nearly 50% cases. Therefore, accurate sonographic assessment of lower limb venous system in clinically suspected cases of DVT can significantly reduce mortality due to embolism [9]. DVT is difficult to diagnose clinically because of discrepancy in location of pain and swelling to the extent and location of thrombus within the venous system. For example, symptoms present in the calf region may be due to thrombosis of femoral veins, and calf vein occlusion can result in thigh pain and swelling. Musculoskeletal and lymphatic etiologies can also mimic the symptoms of acute DVT. DVT can also be asymptomatic, and still can be severe enough to result in death by pulmonary embolism.

13.5.2 Diagnosis of DVT

D-DIMER is a clinically useful serological test. Almost all patients of acute DVT have raised D-dimer levels. It is sensitive (97%), but its specificity is less than 50%. Patients who have undergone recent surgery, recent trauma, malignancy, and sepsis also have raised D-dimer levels. However, it has a negative predictive value of 97%; hence, DVT can be excluded easily. D-dimer along with clinical assessment has been shown to reduce the need for noninvasive tests [10].

VENOUS DOPPLER with high sensitivity (95%) and specificity (100%), being simple and noninvasive with no ionizing radiation, plays an important role in the diagnosis of DVT [11]. **Further** imaging studies including CT venography (CTV) or magnetic resonance venography (MRV) are planned if there is clinical suspicion about the diagnosis or to exclude proximal obstruction either by intraluminal thrombosis or extrinsic venous compression [8]. However, CT and MR are relatively expensive than USG. They are reserved for evaluating the more proximal venous occlusions in cases where ultrasound examination is not satisfactory. Considering the overall cost, specificity, and sensitivity of different testing options, ultrasound turns out to be screening test of choice for deep venous thrombosis. ULTRASOUND examination should integrate B-mode imaging, compression by transducer, color flow Doppler imaging (CFDI), and spectral Doppler analysis to complete the study of the venous structures of the lower extremity. Contrast agents and harmonic imaging can be used in the near future, in cases having uncertainty regarding complete venous occlusion. The transducer choice depends upon the patient built and depth of vessel under evaluation. 5 to 10 MHz linear transducer is appropriate for an average patient. Linear array transducers are preferred for imaging long segments of vessels more rapidly.

13.5.3 Normal Findings

Four following parameters of normal veins are assessed using Doppler imaging:

- Respiratory phasicity
- Spontaneous flow
- Augmentation
- Transducer compression

The variation in venous flow during each respiratory cycle is termed respiratory phasicity. In inspiration, there is an increased intra-abdominal pressure resulting in compression of the inferior vena cava and a decrease in the color Doppler signal and vice versa during expiration (Fig. 13.4). In a normal venous system, augmentation can be demonstrated with distal mechanical compression and Valsalva maneuver. Increased venous diameter and increased Doppler signal indicate augmentation of flow in normal vessels (Fig. 13.5). Spontaneous venous flow can be easily detected in the large lower limb vessels using color flow Doppler imaging. A normal vein has unidirectional flow, is compressible, and has no internal echoes on B mode. The transducer is held transverse to the vein to demonstrate compressibility. An adequate amount of pressure sufficient is then applied with the transducer which causes the collapse of vein lumen (Fig. 13.6). Unidirectional flow can be best identified with color flow Doppler imaging (Fig. 13.7). Diagnosis of acute DVT depends on the presence of all or any of the following findings: incompressible and distended veins with an intraluminal obstructive material, lack of color filling of the vein in color Doppler, and absence of flow on spectral Doppler interrogation of the affected segment (Fig. 13.8). Fresh thrombus is anechoic or hypoechoic, and it becomes increasingly echogenic as it matures. In addition, fresh thrombus has a tendency to expand the vein and make it look rounder and fuller than a normal vessel [12]. Fresh thrombus is non-adherent to the vein wall; therefore, some blood may be seen around the periphery of the clot in the vein on color Doppler (Fig. 13.9). Another appearance which may be seen in early thrombosis is that of a thin tail of thrombus extending up the vein from its origin and lying free in the lumen of the vein. Older thrombus becomes increasingly echogenic, is adherent to the vein wall, and contracts as it becomes more organized and fibrotic. This may result in the vein being reduced to a relatively small echoic structure that may be difficult to locate

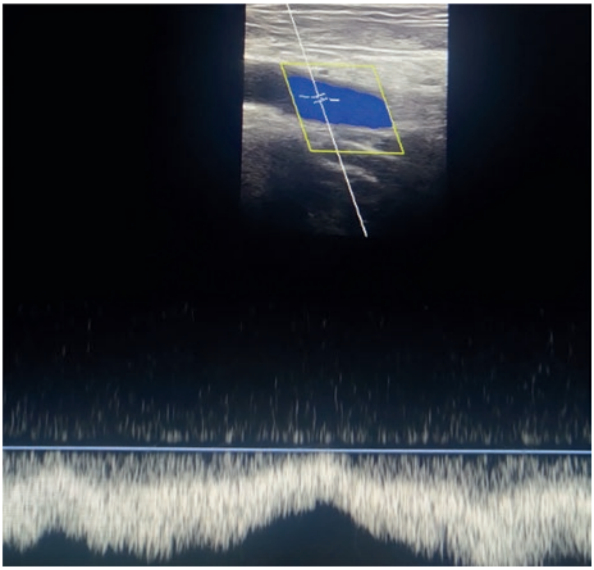
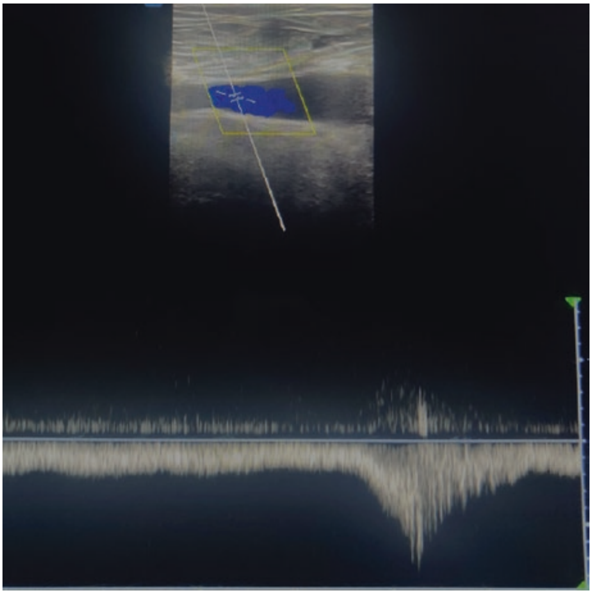


Fig. 13.4 Normal cardiac and respiratory phasicity

Fig. 13.5 Normal augmentation in deep veins on calf squeezing



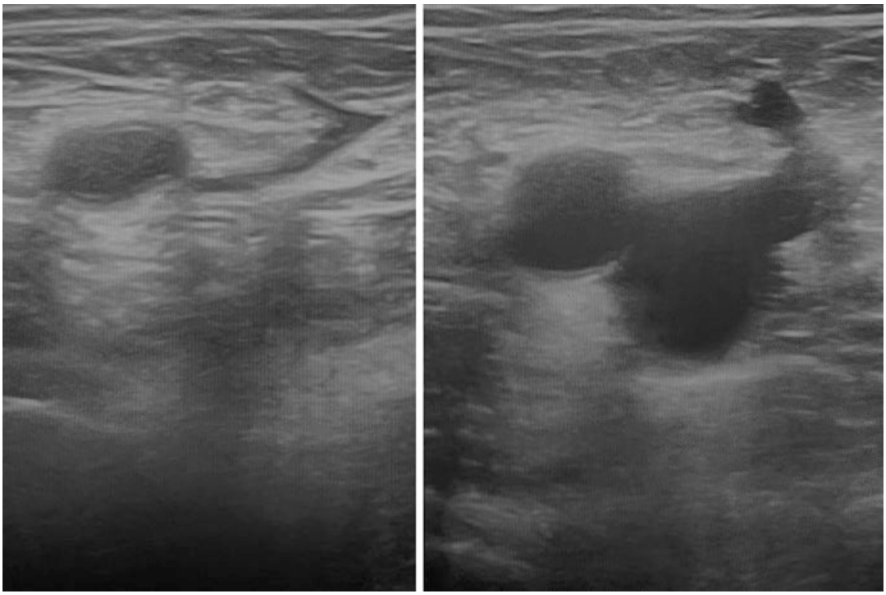


Fig. 13.6 Normal compressibility of veins

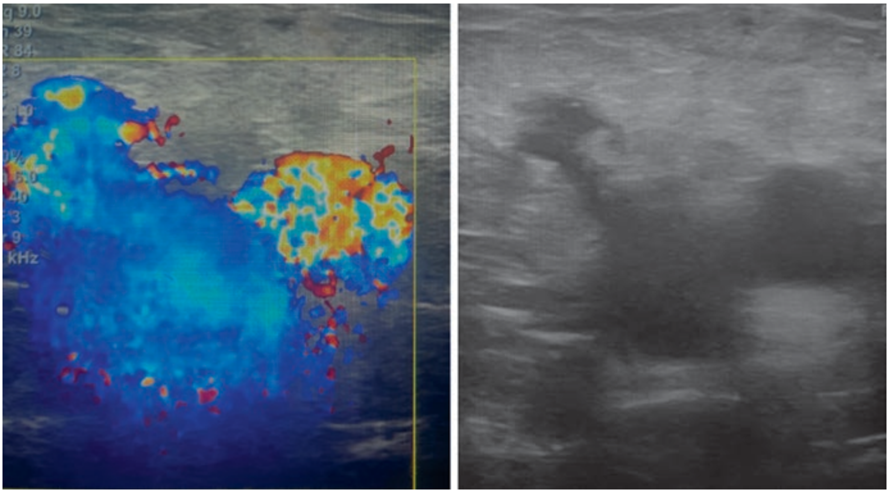


Fig. 13.7 Classic "mickey mouse" appearance of sapheno-femoral junction showing normal spontaneous color flow

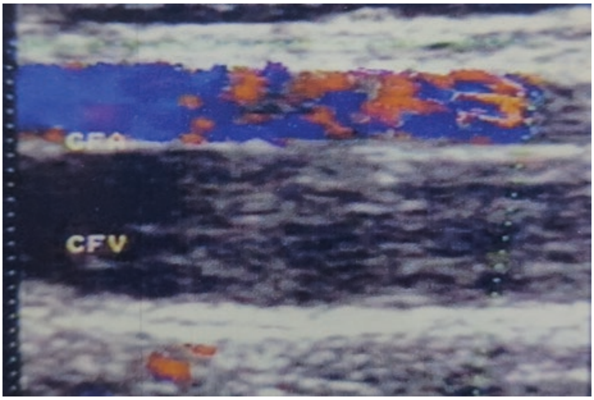


Fig. 13.8 Echogenic thrombus in lumen of common femoral vein

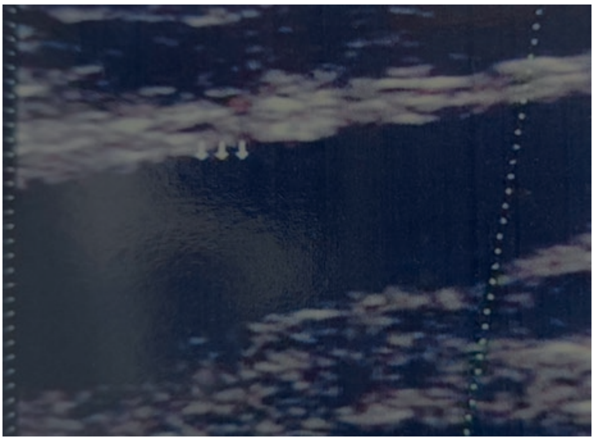


Fig. 13.9 Anechoic fresh thrombus in the lumen of vein. No color flow on Doppler study

(Table 13.3). Despite the high accuracy of the ultrasound in the detection of DVT in the thighs, some limitation could exist like the morbid obesity, marked edema, and the overlying limb casts in some patients (Table 13.4) Therefore one may require CT venography or MR venography if diagnosis is suspicious on USG. CT venography (CTV) has a wider view not only for the pathology but also regarding the complex anatomical details especially in the hardly accessible veins by ultrasound (like iliac, profunda femoral, and the central veins); moreover, it helps in detection of soft tissue and osseous abnormalities. Sources of extrinsic compression of the iliac veins can also be identified by CT. Recently, CT venography has been recommended as a quick and safe means to evaluate the deep venous system after multidetector row CT (MDCT) angiography of the pulmonary arteries (within the same examination), particularly if the patient is clinically unstable and requires immediate diagnosis. This method has a sensitivity between 71–100% and is 93–97% specific. The positive predictive value is 53–92% and negative predictive value is between 92 and 97%. However, the estimated median cumulative effective radiation dose is 8.26 mSv for all patients with an effective gonadal dose of 3.87 mSv. This dose is more than 300% of the median effective dose for CTA of the pulmonary arteries (2.5 mSv). Hence, the dose must be significantly reduced before this can be used as a routine clinical method to evaluate for DVT in clinically stable patients, particularly for those who are young [13]. MR venography is particularly useful in detecting femoral and iliac vein thrombi and can help in determining proximal extent of disease in these vessels [14] (Froehlich et al. 1997). Newer techniques like venous enhanced subtracted peak arterial (VESPA) MR venography, flow-independent MR venography, and direct thrombus MR imaging may allow MR to play a more significant role in DVT imaging in the future [15, 16].

Table 13.3 Distinction between acute and chronic thrombus

Acute	Chronic
Can be anechoic/hypoechoic	Echogenicity increases with time
Causes vein to expand	Causes vein to contract
Some compression of vein is possible	Vein is incompressible
Thrombus lies freely in the vessel lumen or is loosely adhered to the wall	Clot is adherent to the vessel wall
Collaterals are absent	Multiple collateral channels develop with time in the surrounding tissues

Table 13.4 Pitfalls in diagnosis of DVT by USG

• Dual thigh and popliteal vein
• Non-occlusive thrombus
• Swollen/edematous/fat legs
• Segmental calf and iliac vein thrombus
• Segmental iliac vein thrombus

13.6 Acute Superficial Thrombophlebitis

It usually affects the superficial veins or their tributaries either in normal or varicose veins and is more common in the lower extremities; however, it is usually a benign condition unless complicated or extended to involve the deep venous system. Key questions in cases of superficial thrombophlebitis concern the location and extent of the thrombosis, as well as its proximity to the deep venous system at the sapheno-femoral or sapheno-popliteal junction. Migratory thrombophlebitis, especially without good cause, may be an indication for a more detailed evaluation of the patient to determine whether a malignant lesion exists. This evaluation should include selective application of serum carcinoembryonic antigen (CEA) testing, prostate-specific antigen (PSA) testing, colonoscopy, computed tomography (CT), and mammography. All patients with superficial thrombophlebitis above the knee should undergo duplex US as the initial diagnostic modality of choice to rule out DVT. When the patient has superficial thrombophlebitis below the knee, duplex ultrasound is indicated for signs and symptoms consistent with DVT (e.g., asymmetrical swelling, erythema, pain). Superficial thrombophlebitis in lower-extremity varicose veins has an extremely low incidence of DVT. On ULTRASOUND, thrombosed veins may appear thickened or inflamed on US with echogenic content in lumen, but the most accurate diagnostic finding is a lack of compressibility of the vein.

13.7 Chronic Venous Insufficiency

In limbs affected by DVT, 50–80% will recanalize within months or years after the event. Sometimes previous thrombosis may not clear completely, resulting in chronic obstruction and damage to the valves [17]. This damage results in loss of the protective action of the valves so that a continuous column of blood is present between the heart and the tissues of the calf, ankle, and foot which exerts hydrostatic pressure on tissues and interferes with transfer of nutrients resulting in local inflammatory responses, which ultimately leads to development of reticular veins, eczema, skin discoloration, edema, and venous ulceration. The pattern of damaged and incompetent veins can be defined using Doppler ultrasound to examine the deep and superficial veins in order to identify thrombosed or partially recanalized veins. Incompetent venous segments together with incompetent perforating veins can be mapped out and appropriate surgical or medical techniques can be applied. Ultrasound apart from diagnosis also has a major role in the localization of catheters and ablation devices used in the treatment, as well as monitoring the progress of these treatments.

13.8 Technique of Examination

The patient is best examined standing, or with a large degree of head-up tilt if the couch can be elevated. Various techniques can be used to assess competence or incompetence of a venous segment. The most convenient method for general assessment is to squeeze firmly and then release the patient's calf, or lower thigh, to promote forward flow. Incompetent valves will allow reverse flow back through them after forward flow has ceased, whereas competent valves will stop any reverse flow. Alternatively, proximal compression may be applied to induce reverse flow. Getting the patient to perform a Valsalva maneuver will also show incompetent segments, but there are two disadvantages to this technique. Firstly, the effect will only demonstrate reverse flow as far as the first competent valve is considered, and any incompetent segments below this will not be demonstrated. Second, it is quite difficult to explain to many patients the exact nature and method for performing a Valsalva. Reflux can be defined as reverse flow occurring after the cessation of forward flow. It is significant if it lasts >0.5 s in the superficial, deep femoral, and calf veins [18]. For the femoro-popliteal veins, a cutoff of 1.0 s is used as their larger diameters and smaller number of valves are thought to contribute to slower valve closure rates. Shorter periods of reversed flow may be seen in normal veins and represent the short period as the valve cusps come together and blood in the venous segment settles under the influence of gravity. The patency and competence of the deep and superficial veins of the thigh are assessed down to the level of the knee. While examining the great saphenous vein the presence of incompetent perforators should be sought, especially if the vein becomes incompetent at a level below the sapheno-femoral junction. These can be identified most easily by scanning down the vein transversely while applying recurrent compression to the calf or lower thigh and looking for outward flow with color Doppler. The perforators are seen piercing the fascial layer. The commonest of these perforating veins is in the lower thigh at the level of the junction of the middle and lower thirds of the great saphenous vein and is called the mid-thigh perforator vein. The patient is then turned to examine the popliteal region. The veins in the popliteal fossa are assessed and the sapheno-popliteal junction is examined. The level of the sapheno-popliteal junction should be noted, especially if this is not in the expected location.

13.9 Muscular and Tendinous Disorder

13.9.1 Muscle Contusion or Hematoma

They occur as a result of direct trauma or spontaneously in patients treated with anticoagulants, precipitated by trivial trauma or even in the absence of any history of trauma. In **USG** contusion may appear as focal intramuscular swelling that may resolve with no residual abnormality over time. In mild cases, however significant lesions and hematomas may show variable appearance on ultrasound, they may present as cyst-like, hypoechoic, hyperechoic areas, or mixture of different echogenicities; then over a period of time, some hematomas may show more hypoechoic appearance with internal echoes, debris, and some septations and even fluid-fluid level may be seen; however, hematomas may resolve completely or show residual scarring [19]. On MRI, muscle edema may be diffuse or focal and the edematous muscles are swollen due to large fluid contents, so fluid-sensitive sequences (e.g., STIR sequence) are specifically used in the detection of muscle. In muscle contusion, a feathery pattern of a high T2 signal is identified, with possible edema signal in the overlying subcutaneous fat and in the deep portion of the affected muscle [20].

13.9.2 Muscle Strain and Tears

Muscle strain. It occurs when there is increased activity and is associated with tenderness and occasionally swelling. Muscle tears are commonly seen in the calves and occur as a result of suddenly forced contraction and typically at the myotendinous junction or at the muscle bellies and sometimes the tendon itself ruptures with or without gapping [21]. Muscle strain injuries are seen by USG and are graded according to the percent of the affected area to the whole muscle, starting from small hypoechoic muscle disruption foci not exceeding 5% of the whole muscle (grade I), then partial tear is diagnosed when the affected area exceeds 5% of the whole muscle (grade II), and complete tear occurs when bunching of the muscle with frayed edges on dynamic stress is identified (grade III) [19].

13.9.3 Tennis Leg

An isolated rupture of the medial head of the gastrocnemius muscle, usually at its distal musculotendinous junction, results in TENNIS LEG. Tears in this muscle and its tendon are also included under the term “tennis leg” [22]. A secondary DVT can occur as a complication. Tennis leg occurs more commonly in male athletes with poorly conditioned muscles. Secondary DVT is a common complication [23]. USG shows hypoechoic fluid collection deep to the medial gastrocnemius and superficial to the soleus muscle, prominent at the level of the myotendinous junction. There is disruption of the normal pennate pattern of the muscle close to its interface with the soleus and plantaris muscle. An anechoic collection representing hematoma can also be noted. Fluid-sensitive sequences in MRI show increased signal intensity deep to the medial gastrocnemius and superficial to the soleus muscles. Focal areas of muscular disruption in deep part of the medial gastrocnemius along with muscle edema can also be noted. It is important to distinguish tennis leg from acute DVT, as treatment with anticoagulation can increase the risk of bleeding within the affected muscle which can be grave for the patient [24].

13.9.4 Calcific Myonecrosis

It is a rare soft tissue disorder, which mimics the presentation of acute DVT. It is assumed to arise secondary to compartment syndrome or post-trauma-related necrosis and fibrosis, although the exact pathophysiology is unknown [25]. There is repeated intralesional hemorrhage with subsequent calcification and mass formation. The mass is expansive and can compress veins to mimic the symptoms of a DVT. The typical presentation is presence of a fusiform mass in the lower leg long time after a traumatic event [26]. **USG** of the site of the swelling demonstrates a relatively defined heterogeneous mass-like lesion with internal hyperechoic areas casting posterior acoustic shadow suggestive of calcifications and hypoechoic areas of necrosis. Soft tissue components can also be noted in the mass. Increased Doppler neo-vascularity may also be present. Fusiform masses with sheet-like calcification and pressure erosions are some of the features that can suggest diagnosis of calcific myonecrosis on MRI.

13.9.5 Pyomyositis

Muscle infection is caused by a bacterial pathogen that usually occurs in immunocompromised patients; thereby edema may affect a single muscle or may involve a group of muscles. However, the infection could affect the muscles from the deeper osseous structures or deep-seated (complicated) cellulitis [20]. In **USG** muscle abscesses appear as intra/intermuscular complex cystic collection with thick shaggy walls and internal debris; sometimes air echogenicity may be present. On power Doppler, a marginal vascularity in the abscess wall can be detected. CT and MRI may demonstrate rim enhancement pattern which is considered as a discriminative feature of pyomyositis and indicates abscess formation, but this finding may not be present in early stages of the disease process [20].

13.9.6 Tenosynovitis

It is an inflammatory condition affecting the synovial covering of the tendons. It may be infectious or noninfectious in origin. Ultrasound reveals distended tendon sheaths by hypoechoic fluid collection with possible synovial thickening and hyperemia on power Doppler. Subcutaneous edema of the affected region can be seen as well; however, when the fluid collection shows turbidity or associated gaseous echogenicity inside, the possibility of infectious causes is considered. MRI findings include tendon sheath distension with a fluid signal, associated synovial proliferation, and synovial enhancement on contrast administration. The main etiologic factor could not be determined by the MRI solely; however, bilateralism of condition may favor noninfectious causes. Small fibrinous bodies called "rice bodies" may be seen in certain inflammatory conditions (like rheumatoid arthritis, TB, and sarcoidosis) affecting the synovial lined structures like joints and tendon sheaths and are usually associated with focal swelling.

13.10 Osseous and Joint Space Related

13.10.1 Baker's Cyst

Baker's cysts, synovial cysts, or popliteal cysts are the most commonly encountered nonvascular popliteal masses. Classically, Baker's cysts do not contain a true synovial lining and are filled with synovial fluid which is gelatinous in consistency [27]. These cysts comprise of a fluid-filled sac and a neck which arises from the space between the medial head of gastrocnemius muscle and the semimembranosus tendon. They are located posteriorly in the popliteal fossa and present with knee pain, swelling, and knee joint stiffness. When these cysts rupture, the fluid contents track down in inter- and perimuscular fat planes inducing inflammation with mimicking clinical picture of acute DVT. These cysts can be incidentally found in up to 49% of patients on USG when performing a DVT scan of the lower extremity [28]. USG features include a well-defined anechoic cystic lesion in popliteal fossa with posterior acoustic enhancement. Some cyst may show internal echoes suggesting infection. A neck is noted arising from the space between the medial head of gastrocnemius and semimembranosus tendon. This looks like a "talk bubble" in the transverse plane. There is no Doppler flow unless there is an associated infective or inflammatory process. When there is Doppler flow, or some solid components are noted in the cyst, imaging with MRI is usually indicated for further evaluation. MRI features include a high signal intensity mass in the gastrocnemius/semimembranosus bursa on T2-W images. Presence of T2-W hyper-intense fluid in the intermuscular fat planes along with a Baker's cyst indicates rupture of cyst with leakage. Complicated Baker's cysts may have thickened walls, internal hemorrhage, and intracystic debris which can be misinterpreted for a complex lesion. An important feature in differentiating a Baker's cyst from a DVT is the presence of a neck between the medial head of gastrocnemius head and semimembranosus tendon. For simple cysts, approximately two-thirds of patients benefit from treatment through image-guided aspiration and injection of steroid [29].

13.11 Joint Effusion and Septic Arthritis

The synovial joints have a joint capsule that is lined by synovium which normally secretes minimal synovial fluid; when this fluid is secreted in excess amount in certain pathological conditions, then it is called joint effusion, but when this fluid became infected, the condition is called septic arthritis that may necessitate prompt arthrocentesis. Septic arthritis occurs at any age with a predilection to the extreme age groups (both elderly individuals and newborns) as well as in immunocompromised patients like diabetics. Large joints are often involved with the knee; hip and shoulder joints are the most commonly affected in a respective pattern [30]. Ultrasound is particularly helpful in pediatrics as it can assess joint spaces for effusion and subperiosteal collections and even detects osteomyelitis earlier than plain radiography [31]. Color and power Doppler helps in assessing hyperemic changes in the inflamed soft tissues. MRI findings: MRI with contrast enhancement as well as the fat suppression sequences are proved to have high sensitivity and specificity (100% and 77%, respectively); the findings include joint effusion, synovial thickening, perisynovial edema, bone marrow changes, high signal in T2WIs, and underlying osteomyelitis if present, and on contrast-enhanced examination findings could be synovial enhancement; enhancing fluids with pockets of fluid outpouchings can be seen [32].

13.12 Miscellaneous Causes

There are other causes of edema that should be considered during clinical and radiological assessment of limb swelling. It includes edema due to underlying pathology in the heart, liver, and kidney. Apart from subcutaneous edema in limbs, USG can also demonstrate changes in the above mentioned organs. Idiopathic edema is common in young females due to pathologic fluid retention in upright position. Patients also complain of face and hand edema apart from leg edema. The diagnosis is usually clinical after ruling out systemic causes. Another etiology that one should keep in mind while performing radiological examination is lymphedema.

Secondary lymphedema is much more common than primary, and the cause is generally apparent from the history. The most common causes of leg lymphedema are tumor (e.g., lymphoma, prostate cancer, and ovarian cancer), surgery involving lymphatics, radiation therapy, and infection (filariasis or bacterial infection) [33]. Chronic lymphedema is usually distinguished from venous edema based on characteristic skin changes, absence of pitting, and history of an inciting cause. The skin becomes thickened and darkened and may develop multiple projections called lymphostatic verrucosis. The dorsum of the foot is prominently involved and may have a squared-off appearance [34]. Ultrasound features of lymphedema are volumetric changes (a minimal increase in the thickness of dermis) and an increase in the subcutaneous layer, and an increase, decrease, or no change in the muscle mass and structural changes (hyperechogenic dermis and hypoechogenic subcutaneous layer). It allows for an assessment of soft tissue changes but does not give information about anatomy [35]. Computed tomography (CT) scanning can be used not only to confirm the diagnosis but also to monitor the effect of treatment. The common CT findings in lymphedema include calf skin thickening, thickening of the subcutaneous compartment, increased fat density, and thickened perimuscular aponeurosis. A typical honeycomb appearance is seen in most patients.

Lymphoscintigraphy may be indicated to differentiate between early lymphedema and venous edema. It is done by injecting radioactive tracer into the first web space and monitoring lymphatic flow by gamma camera. The distinction cannot always be made because chronic venous insufficiency can lead to secondary lymphedema with abnormally delayed lymph drainage on lymphoscintigram [35]. MRI can aid in differentiating lymphedema, phlebedema, and lipedema of the lower limb. T1- and T2-weighted transaxial sequences can be performed before administration of gadolinium tetraazacyclododecane-tetraacetic acid (DOTA), and

T1-weighted spin-echo sequences are performed after administration of Gd-DOTA in each patient. Images of patients with lipedema will show homogeneously enlarged subcutaneous layers, with no increase in signal intensity at T2-weighted imaging or after Gd-DOTA administration. Patients with phlebedema will show areas containing increased amounts of fluid within muscle and subcutaneous fat. In lymphedema, a honeycomb pattern above the fascia between muscle and subcutis can be observed, with a marked increase in signal intensity at T2-weighted imaging. After Gd-DOTA administration, there will be only a slight increase in signal intensity in the subcutis in lymphedema and phlebedema and a moderate increase in signal intensity in muscle in phlebedema [36].

13.13 Summary

Leg swelling is common and may be caused by a wide variety of disorders. Causes may be both acute and chronic. Of the acute causes most important is to rule out DVT because of the risk of pulmonary embolism which can be life-threatening. Therefore, a quick and accurate diagnosis by proper selection of the imaging study of choice is important. Keeping the anatomical spectrum of causes in mind while evaluating patients can help a radiologist to reach a set of differential diagnosis. Ultrasonography is the initial preferred modality of choice in evaluating lower limb edema. It is inexpensive, simple, and non-ionizing radiation with a high sensitivity and specificity especially in diagnosing DVT. B-mode scan, color flow Doppler imaging, and spectral analysis should be used cohesively. Non-compressibility, lack of color flow, and loss of respiratory phasicity indicate the presence of thrombus in a vessel. MR and CT venography are indicated in cases where there are limitations to USG (obesity, segmental calf vein, and iliac vein thrombosis). Chronic venous insufficiency is usually a sequela to DVT that can be diagnosed on USG by demonstrating reflux at sapheno-femoral and sapheno-popliteal junction. Once DVT has been ruled out, one should focus on the other acute causes that can mimic DVT (ruptured Baker's cyst, muscle hematomas, cellulitis, acute superficial thrombophlebitis, ruptured muscles and tendons, myositis, septic arthritis in neonates, etc.). In cases of chronic edema systemic causes should be ruled out. Lymphedema should be taken into consideration. Ultrasound cannot differentiate between venous and lymphatic edema; therefore, lymphoscintigraphy is indicated. Recently, studies have shown that contrast and non-contrast sequences in MR can differentiate between lipedema, phlebedema, and lymphedema.

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