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Advanced Medical Imaging Consultants, PC

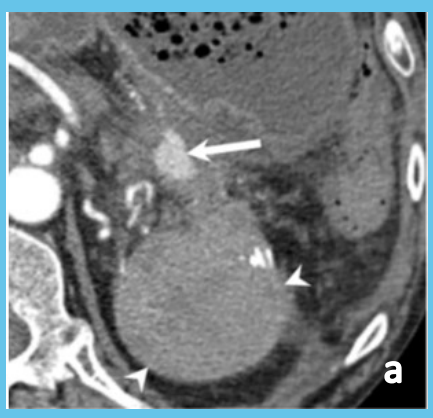
Role of CT in the Evaluation of Acute Gastrointestinal Bleeding

By Alistair Jordan, DO

Acute gastrointestinal (GI) bleeding is a commonly encountered problem. The rate of bleeding occurring in the upper GI tract is 100–200 per 100,000 persons annually and in the lower GI tract is 20.5–27.0 per 100,000 persons annually. Although 80%–85% of cases of GI bleeding resolve spontaneously, it can result in massive hemorrhage and death. Radiology plays a critical role in the detection of GI bleeding.

GI bleeding has been categorized into upper and lower GI tract. The anatomic marker is the ligament of Treitz; this is defined as a suspensory muscle of duodenum. GI bleeding is further categorized as overt or occult. Overt GI bleeding refers to visible hemorrhage such as hematemesis, hematochezia, or melena. Occult GI bleeding cannot be seen; rather, it is detected on the basis of positive fecal test and presence of anemia due to iron deficiency when other causes of anemia have been excluded.

There is a broad work-up for various types of GI bleeding including endoscopy, angiography and other imaging modalities. This article will focus on acute, overt GI bleeding and the role of CT imaging. Historically, radiologic evaluation of GI bleeding has been performed by nuclear medicine using technetium 99m (99mTc). It is the most sensitive radiologic technique for the identification of active bleeding, enabling the detection of bleeding at rates as low as 0.1–0.5 mL/min. Unfortunately there are limitations with 99mTc such as limited availability and a delay of several hours before the examination is initiated with often poor anatomic localization of the bleeding (Figure 1).



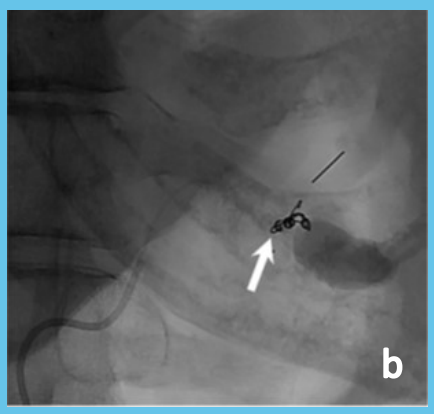


Figure 2: (a) CT angiogram demonstrates active bleeding from a gastric artery pseudoaneurysm with an adjacent large hematoma. (b) Angiography and treatment performed by interventional radiology shows coil embolization of the site of hemorrhage.

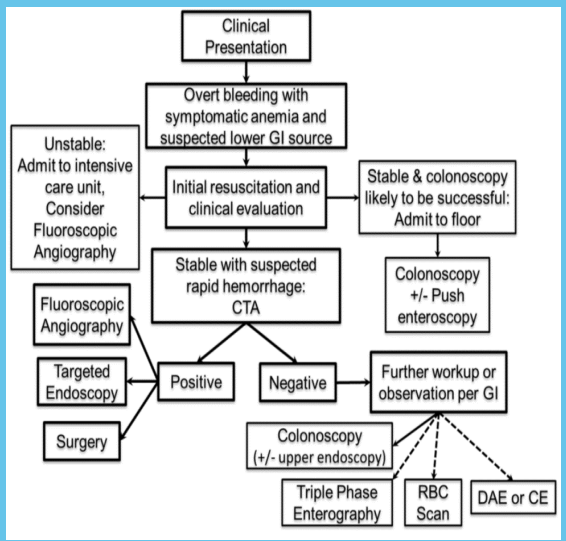
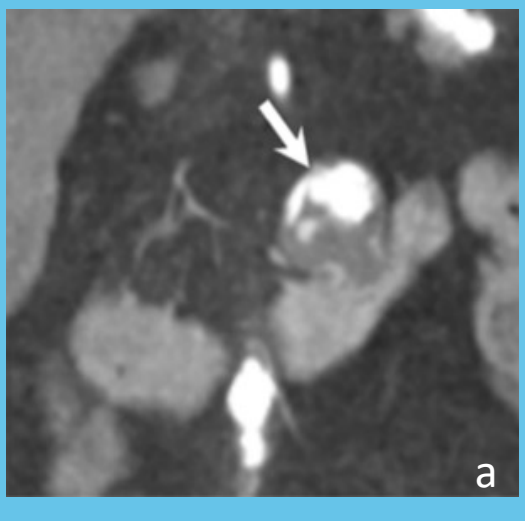


Figure 1: An example of how to work-up acute, lower GI bleed.

CT angiography for evaluation of acute GI bleeding is an excellent option owing to its speed and widespread availability. Various multiphasic protocols exist. Typically, we use an arterial phase followed by a 120 second delayed phase. Some centers include a non-contrast phase as well. We do not include oral contrast as this can obscure the site of bleeding. CT angiography is more sensitive than fluoroscopic angiography for detection of active extravasation, but less sensitive than RBC scanning, and is able to depict bleeding at a rate of 0.3–0.5. The main benefit is speed, anatomic localization of the bleeding, as well as the ability to image structures outside of the GI tract. In fact a meta-analysis of data from 672 patients with moderate to severe UGIB and/or LGIB revealed an overall sensitivity of 85% and a specificity of 92% for detection of the bleeding site (Figures 2 and 3).

Role of CT in the Evaluation of GI Bleeding Continued…



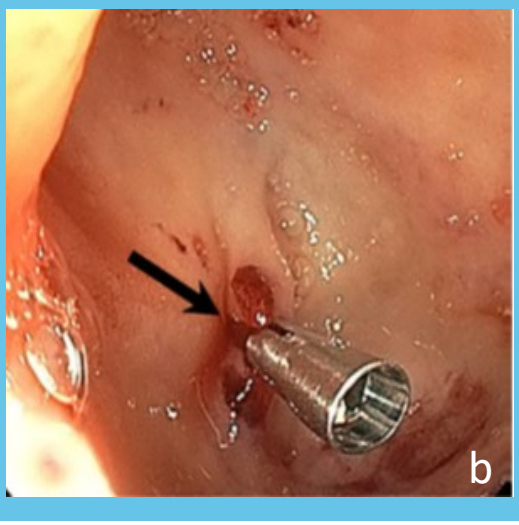


Figure 3: (a) CT angiogram performed on a patient with history of Crohn's disease in the setting of hemodynamic instability and hematemesis. CT imaging reveals active bleeding in a diverticulum of the duodenum. (b) Endoscopy was performed and the patient was treated with clip placement and epinephrine injection.

A negative-result CT also provides helpful prognostic information. In the absence of GI bleeding seen on CT these patients are unlikely to require emergent surgical or interventional radiology procedures. For example, in a study by Sun et al, 27 of 33 patients who had a negative CT angiogram were discharged from the hospital without intervention and had no recurrent bleeding within a median follow-up period of 25.6 months. It is also helpful for inpatients that may have failed complete assessment of the GI tract with endoscopy.

There are limitations to the use of CT angiography. First, the exam is therapeutic only. However, endoscopy and colonoscopy has the potential to be both therapeutic and diagnostic. The use of nonionic low-osmolality iodinated contrast material involves a low (0.04%) risk of severe allergic reaction and a possible risk of contrast material–induced nephropathy.

In conclusion, acute GI bleeding is a common scenario that can be life threatening. CT plays a critical role owning to its wide availability, sensitivity, and rapid detection of a potential bleeding source. A positive or negative-result CT has significant impact on patient's treatment and prognosis.

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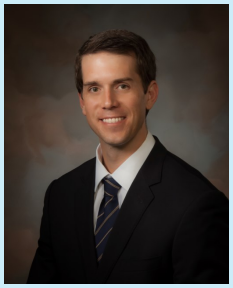


Acute Lower Extremity DVT

By Kenneth Cicuto, MD

State of Treatment:

The incidence of venous disease in the Western hemisphere has not significantly changed in the past 25 years. Venous thromboembolism continues to affect approximately 900,000 individuals annually with healthcare costs reaching billions of dollars per year for acute treatment alone. Chronic venous disease continues to be one of the most common peripheral vascular disorders with at least 1/10 adults reporting some manifestation of the disease.

For many years, patients suffering from venous diseases were limited to a handful of invasive, often limited, surgical options. Over the past several decades, advancements in the basic science, understanding, and treatment of venous biology and pathology have improved treatments and outcomes for patients who suffer from a wide variety of venous diseases. The advent of novel oral anticoagulants, endovenous laser ablation systems, intravascular ultrasound, catheter-directed/pharmacomechanical thrombectomy devices, and endovascular recanalization and stenting techniques have provided safer, less-invasive, and more effective treatment options (Figure 1).

Risk Factors for Venous Thromboembolic Disease (VTE):

Potential reversible risk factors should also be addressed. Common risk factors for VTE include increasing patient age, recent major surgery, polytrauma or fracture, hospital or nursing home confinement, malignancy, prior DVT/PE, obesity, chemotherapy, central venous catheter or pacemaker, superficial vein thrombosis, infection, antiphospholipid antibody syndrome, inherited thrombophilias (factor V Leiden, prothrombin gene mutation, deficiencies of antithrombin III, protein C, protein S), prolonged air travel, family history of VTE, kidney disease, and congestive heart failure. Pregnancy or postpartum period, hormone and selective estrogen receptor modular therapy, and oral contraceptives also serve as independent risk factors for women.

Incidence of recurrent DVT at 1 year of 6.3% and 9.9% at end of 2 years, with an increased risk of recurrent DVT in patients with history of malignancy, unprovoked DVT, proximal DVT, and symptomatic PE. Ipsilateral recurrent DVT has been associated with increased risk for post-thrombotic syndrome (PTS).

Post-Thrombotic Syndrome, (PTS):

PTS, also known as chronic venous insufficiency, has been shown to negatively affect quality of life. Despite anticoagulation, up to 50% of patients with lower extremity DVT will develop some degree of PTS within 2 years. The underlying causes of PTS are not scientifically proven at this time. The working hypothesis is that PTS is related to destruction or injury of the venous valves within the deep veins. In a normal functioning venous system, the venous valves of the deep veins of the leg help pump blood back to the heart and work against gravity. When these valves become damaged or destroyed, a constellation of symptoms may develop including leg heaviness, swelling, pain, cramping, pruritus, paresthesia, skin induration, redness, varicose veins, skin breakdown, painful skin ulcers (venous stasis ulcers), and brownish skin pigmentation changes that may be irreversible (Figures 2 and 3).

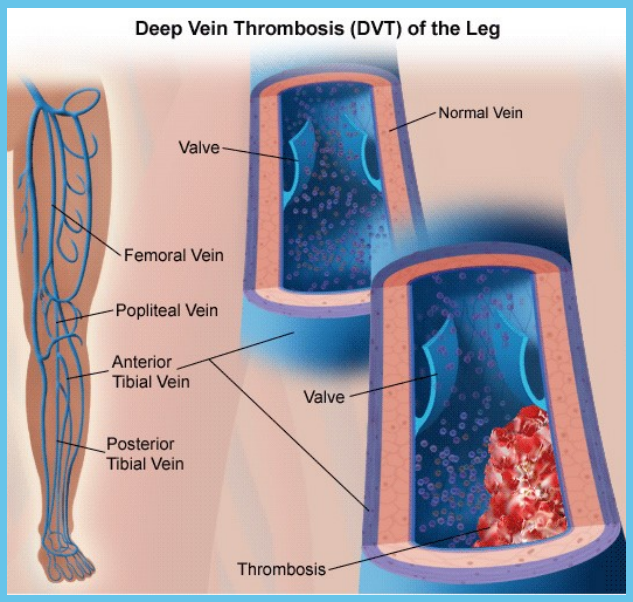


Figure 2: Venous Valve

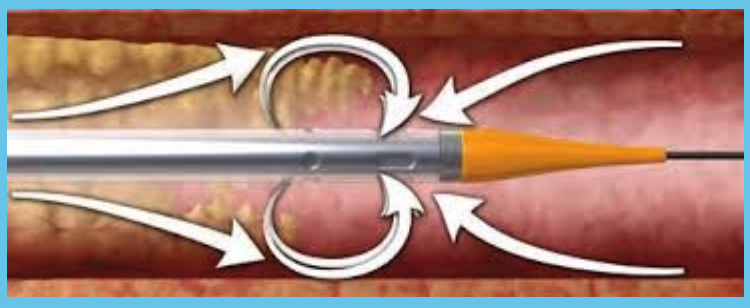


Figure 1: Angiojet

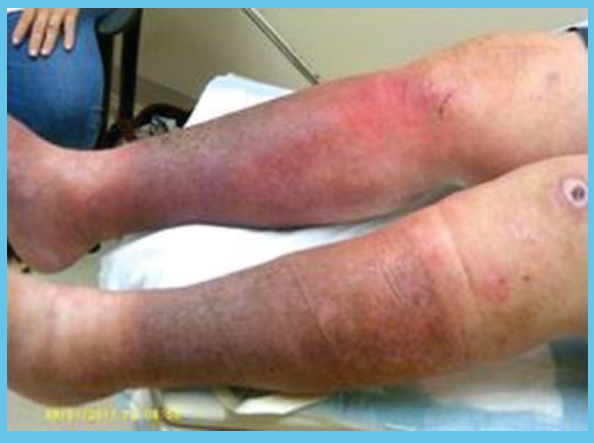


Figure 3: Indurated, Hyperpigmentated Skin

Acute Lower Extremity DVT Continued..

The Villalta scale is a standardized scale used to measure the severity of PTS. The Villalta scale grades the severity of 5 patient-related symptoms (pain, cramps, heaviness, pruritus, and paresthesia) and 6 clinician-rated clinical signs, (edema, redness, skin induration, hyperpigmentation, venous ectasia, and pain on calf compression) each on a scale of 0 (absent) to 3 (severe). A total score of 5-9 represents mild PTS, 10-14 moderate PTS, and a score of 15 or greater or the presence of venous stasis ulcer as severe PTS.

Why Intervene?:

The CaVenT study randomized 209 patients with first time iliofemoral DVT to treatment with conventional anticoagulation vs catheter-directed therapy (CDT) with alteplase. The study found an absolute risk reduction of 14.4% in PTS after additional CDT compared with conventional treatment alone. Watson et al analyzed 17 randomized, controlled trials and found similar results with a one third reduction of PTS in patients with proximal DVT after thrombolysis.

The Thrombus Removal with Adjunctive Catheter-Directed Thrombolysis (ATTRACT) trial, randomized 692 patients with acute proximal DVT to either anticoagulation alone or anticoagulation with thrombolysis, found no significant difference in percentage of patients developing PTS. Both groups demonstrated a near 50% rate of PTS with the thrombolysis group having a higher risk of major bleeding. These results do question the validity of the "open vein hypothesis" and suggest that more research is needed to understand the pathophysiology of PTS. There were trends to improved outcomes within highly symptomatic DVT with central clot (iliocaval) but this did not reach statistical significance. This would point towards recent over-treatment of DVT. A reasonable treatment algorithm would be for endovascular management in the following patient setting: central pelvic clot, severe symptoms and progression on medical anticoagulation. Limb ischemia or caval thrombus with the inclusion of visceral veins, such as the hepatic or renal veins, would also trigger more aggressive catheter based treatments.

Endovascular Treatments:

Our treatment options range from multi-side hole lytic catheters (w or w/o ultrasound transducers, EKOS), balloon maceration, mechanical or aspiration thrombectomy, and venous stenting.

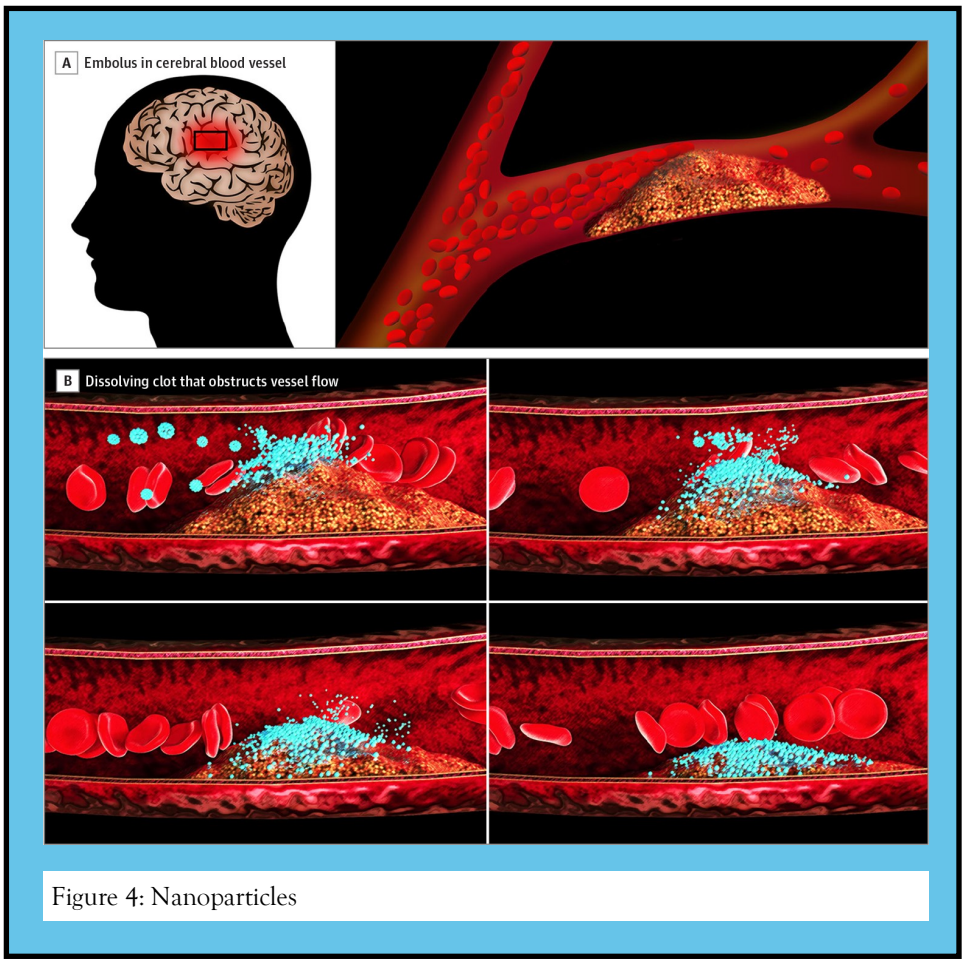


Figure 4: Nanoparticles

Next Steps:

The next frontier for DVT therapy will possibly be in the field of nanotechnology. Nanoparticles represent a new paradigm in drug delivery and therapy with the ability to maximize drug delivery and minimize systemic effects. Nanoparticles may be engineered to directly target thrombus while reducing the hemorrhagic risk of anticoagulant therapy. Nanoparticles have been designed to target specific receptors in the thrombotic cascade including fibrin, activated factor XIII, GP1b, and P-selectin. The Food and Drug Administration has approved some drug delivery nanoparticles and several more are in clinical trials which can be incorporated into DVT therapy. Interventional Radiology is perfectly positioned for future catheter-based therapy using nanoparticles given our ability to selectively target vasculature (Figure 4).

Stay tuned!

Kenneth Cicuto, MD

Diagnosis of DVT

By Amy Hayes, MD

DVT (Deep Venous Thrombosis)

- Affects approximately 900,000 people per year with an estimated incidence of 1.6 cases per 1,000 people
- Untreated lower extremity DVT has a 3% mortality rate (related to pulmonary embolism)
- Among people who have had a DVT, half will have long term complications (post-thrombotic syndrome) – see article by Dr. Cicuto
- One third of patients with DVT/PE will have a recurrence within 10 years
- 5-8% of the US population has one of several genetic risk factors, also called inherited thrombophilias, which increase the risk of thrombosis

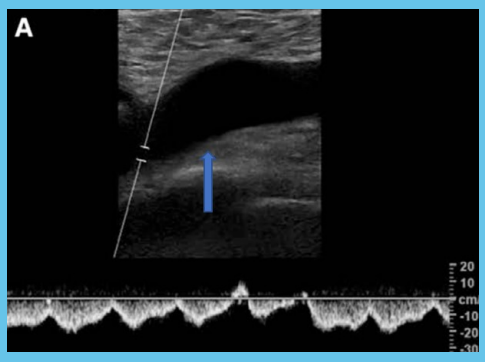


Figure 1: Vessel is anechoic and has a normal waveform with respiratory variation.

Risk Factors for DVT

- Age (relative risk increase—2 per 10-year increase)
- Surgery (orthopedic patients at highest risk: hip 48%, knee 61%)
- Trauma
- History of venous thromboembolism (2-9% increase)
- Primary hypercoagulable states
  - Protein A, C, and S deficiency (10x increased risk)
  - Factor V Leiden (heterozygous 8x increased risk, homozygous 80x)
- Estrogen replacement (2-4x increased risk)
- Immobilization (2x increased risk)
- Pregnancy (0.075% of pregnancies)
- Malignancy (4-6x increased risk)
- In-dwelling vascular device (e.g. PICC line and upper limb DVT) [5]

Diagnosis of DVT

- Ultrasound is the modality of choice
- Venography or CT venography can be used in complex cases or when DVT is suspected but might not be seen by ultrasound. For example IVC, SVC and subclavian vein thrombosis can be difficult to diagnose because these vessels are hard to see with ultrasound.

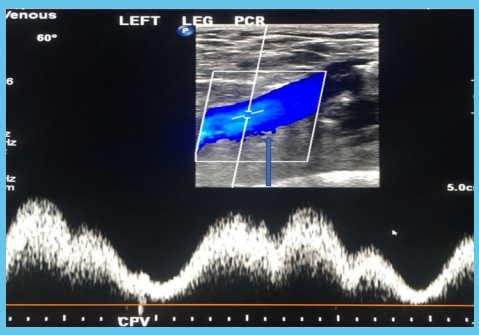


Figure 2: Fills in with color on Doppler.

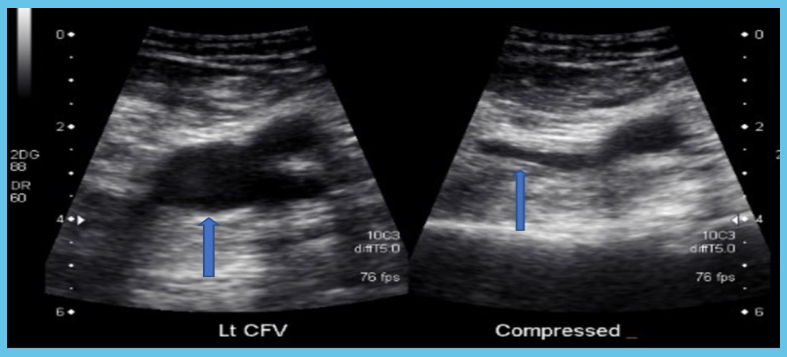


Figure 3: Compresses with pressure from the transducer.

Normal veins are anechoic on ultrasound. They fill with color on color Doppler imaging and have characteristic waveforms that non-pulsatile but may have normal respiratory variation and they are compressible (Figures 1, 2, and 3).

Ultrasound Diagnosis of Acute DVT

Vessel is filled with mixed echogenicity material. Vessel is typically expanded (vessel is typically contracted when DVT is chronic). Vessel does not fill with color signal on Doppler and no waveform is detected. Vessel is noncompressible (Figure 4).

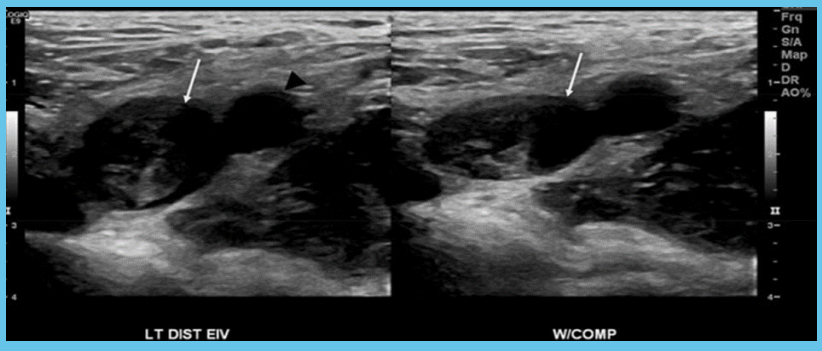
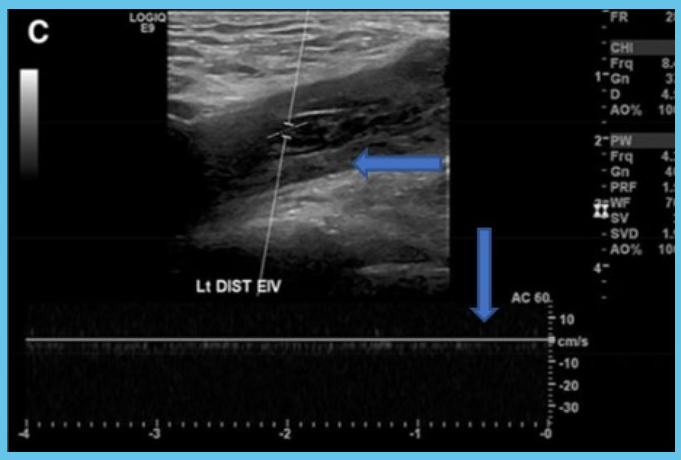
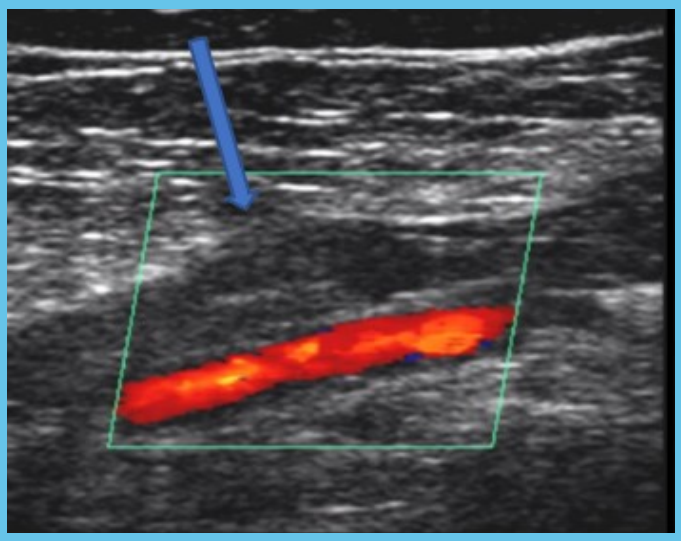


Figure 4: Vessel is noncompressible.

Diagnosis of DVT Continued...





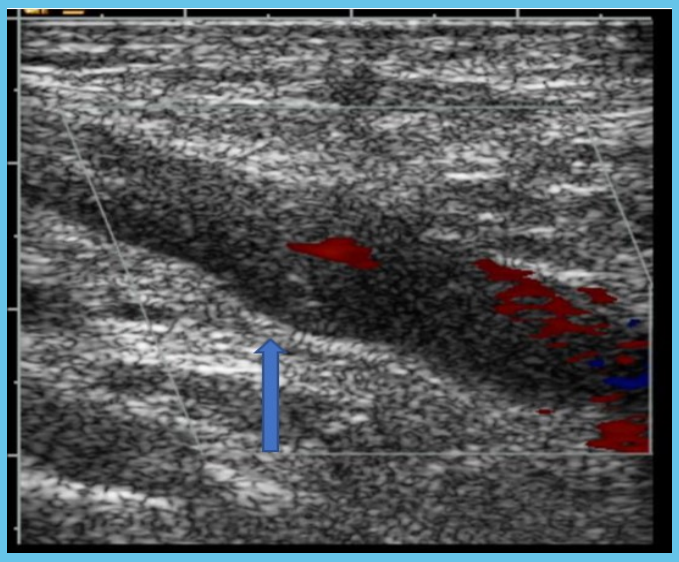


Figure 5: Vessel filled with mixed echogenicity material and there is essentially no color or doppler signal.

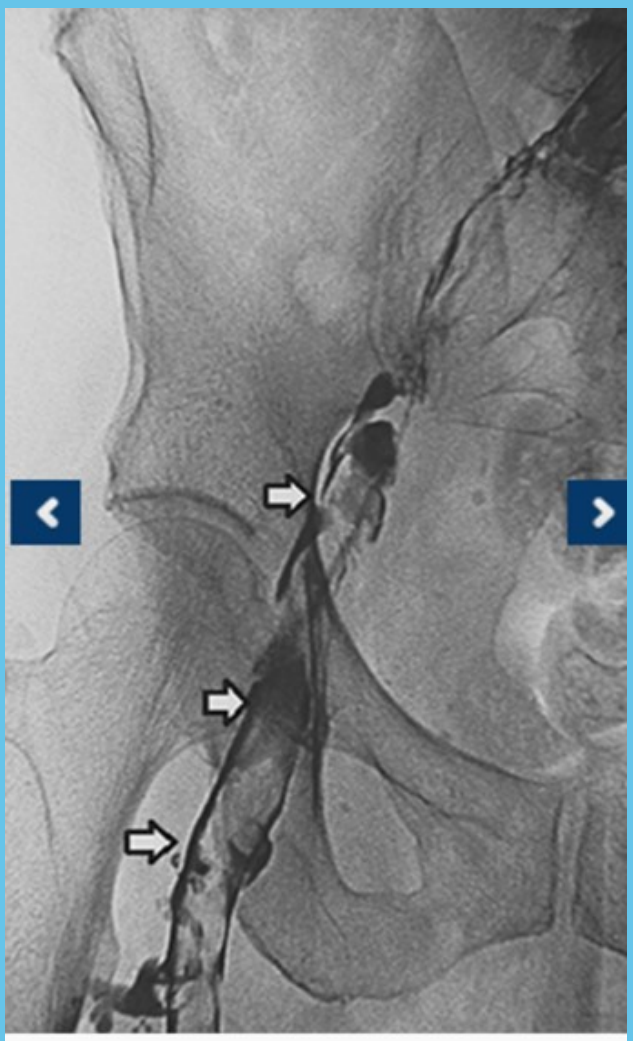


Figure 18.

Frontal image from a catheter venogram shows diffuse thrombosis of the right iliac and upper thigh central venous system (arrows).

Figure 6: Catheter venography demonstrating a DVT.

Amy Hayes, MD

Stroke Imaging

By Nicholas Statkus, MD

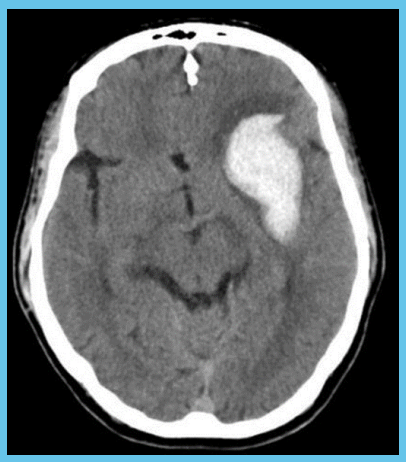


Figure 1: Non-contrast head CT shows a large left sided acute parenchymal hematoma which precludes treatment with IV tPA and additionally explains the patients symptoms. Additional forms such as subarachnoid or subdural hemorrhage if present would be a contraindication to IV tPA.

Strokes used to account for more deaths in the United States, however, treatment and supportive care have improved over the last 10-15 years to where strokes are now the number 5 cause of death in the U.S. Strokes are the **leading** cause of serious long-term disability which translates into a need for long term support for stroke survivors. Stroke treatment had been relatively stagnant since the advent of IV thrombolytic therapy. Over the last few years there has been an extremely active investigation into catheter based thrombectomy in the treatment of stroke. Catheter based clot retrieval has improved significantly in the recent past to where the treatment algorithms for stroke treatment are actively changing.

The standard of care until recently had been treatment of a stroke with IV tPA for patients with symptom onset of less than 6 hours without intracranial hemorrhage. Multiple recent studies have shown benefit of expanding the treatment window beyond 6 hours with catheter based thrombectomy/clot retrieval. The Defuse 3 trial published within the past year is one of the more important recent strokes studies

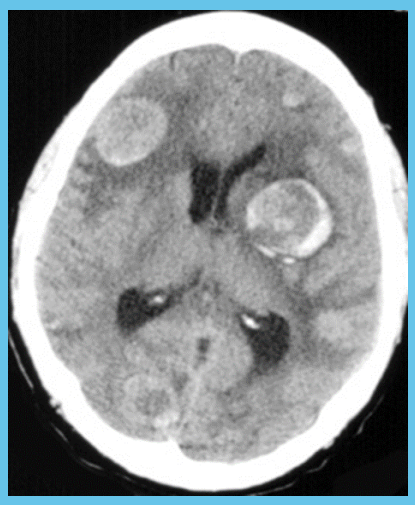


Figure 2: Non-contrast head CT shows multiple dense/hemorrhagic parenchymal metastatic lesions.

which showed improved outcome in patients who undergo catheter based thrombectomy compared to IV tPA The primary outcome of this study was functional outcome between the two treatment groups. 45% of patients who underwent catheter based thrombectomy in this study achieved functional independence and was three times greater than the IV tPA group. One of the modalities used to evaluate stroke patients in this study was CT perfusion to evaluate for brain at risk to infarct if the clot is not dissolved or removed. One of the ramifications of this study will be increased use of CT perfusion in the coming years to triage patients for potential neurointerventional catheter-based clot retrieval. The following discussion is a brief review of CT imaging for strokes including perfusion imaging.

Non-contrast head CT is, and will remain, important as the initial imaging study in the work-up for stroke to exclude intracranial hemorrhage and/or masses which may be an explanation for the patients symptoms (Figures 1 and 2). The presence of intracranial hemorrhage is a contraindication to the usage of iv tpa. Non-contrast head CT may also potentially reveal the presence and size of an acute to subacute infarct. A sizable infarct may be a contraindication to both IV tPA and catheter based thrombectomy, (Figure 3). An acute blood clot within the arterial vasculature causing a stroke can sometimes be visible on a non-contrast head CT as well with the classic example dubbed the dense MCA (middle cerebral artery) sign (Figure 4).

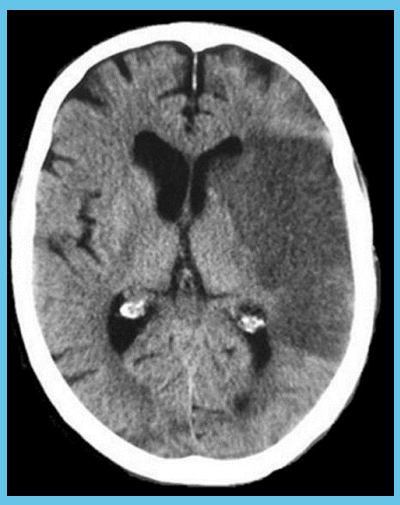


Figure 3: Non-contrast head CT shows a large likely greater than 6 hour old left sided MCA. Due to the size of this infarct, IV tPA would likely not be utilized given the potential for post-treatment parenchymal hemorrhage. The greater the size of the infarct the greater the risk for parenchymal hemorrhage following treatment with IV tPA .

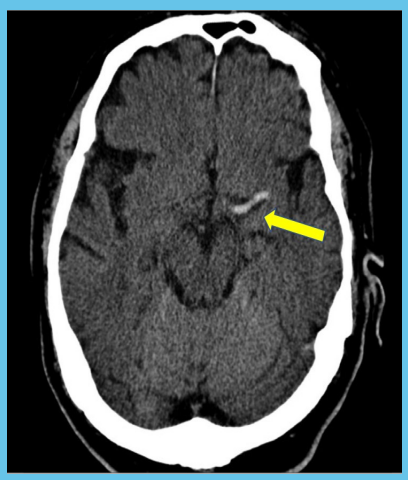


Figure 4: Non-contrast head CT shows a left-sided dense MCA (middle cerebral artery), yellow arrow, in keeping with acute clot within the middle cerebral artery causing the stroke in this patient.

Stroke Imaging Continued..

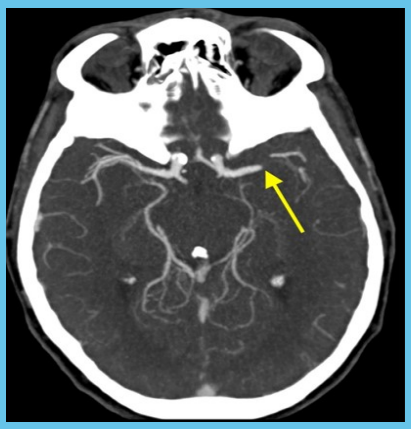


Figure 5: CT angiogram axial image demonstrates clot within the left middle cerebral artery. This clot is in a favorable location for catheter based clot retrieval.

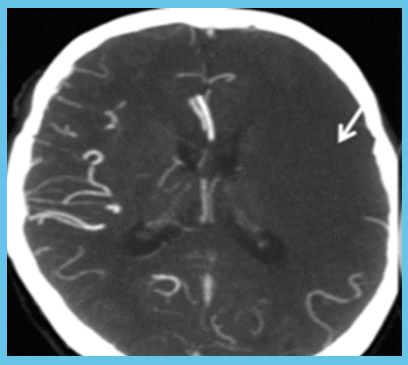


Figure 6: CT angiogram image in a patient with an acute left MCA (middle cerebral artery) clot shows poor collateral blood flow (white arrow) in the distribution of the infarct.

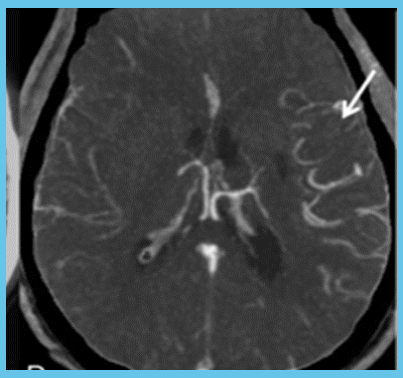


Figure 7: CT angiogram image in patient with a left MCA clot shows good collateral blood flow in the left MCA distribution.

CT angiogram is additionally used at many sites in the imaging work-up of potential strokes to evaluate for a causative arterial thrombus or dissection. CT angiogram is able to localize the presence and size of a stroke-causing clot, figure 5. A CT angiogram can additionally evaluate for the presence of collateral intracranial vasculature if there is an acute thrombus present. The presence of collateral blood flow in the setting of an acute infarct influences how rapidly the infarct will progress. If there is poor collateral flow (Figure 6), the infarct will likely rapidly progress. If there is good collateral flow (Figure 7), the infarct will progress slower and the patient will likely have an improved outcome if the clot can be removed as the ischemic tissue may not progress to an irreversible total infarct.

CT perfusion is the final CT application which can be used in the imaging work-up of stroke patients. CT perfusion is a dynamic acquisition where a volume of brain tissue is continuously imaged over approximately 60 seconds following the injection of iv contrast. Clot/thrombus within an intracranial artery will delay contrast passage through the affected portion of the brain. CT perfusion is able to characterize the brain tissue which is affected by the clot and can additionally characterize the portion of brain which is irreversibly infarcted. Brain tissue which is completely infarcted will take up no contrast. Brain tissue which takes up contrast but at decreased levels in the distribution of an arterial clot is termed a penumbra (tissue which is at risk to completely infarct if not treated) and is the key finding which can triage patients towards catheter based clot retrieval. Multiple software applications are available which post-process the CT perfusion images to create color maps to differentiate between non-treatable infarcted tissue and the tissue at risk for infarct (penumbra) (Figure 8).

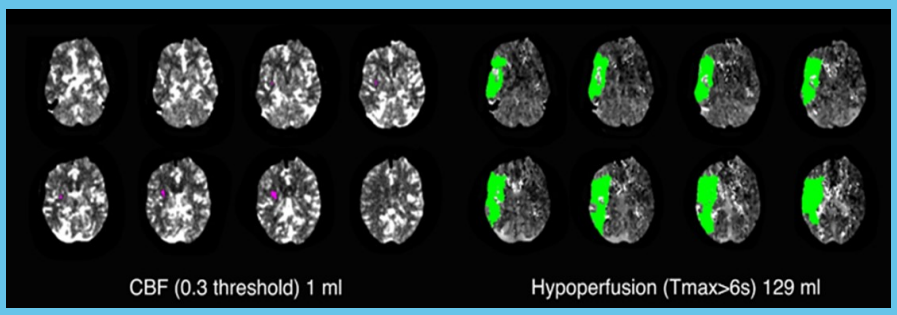


Figure 8: Post-processed image from a CT perfusion study utilizing iSchemaView Rapid software application. There is a right MCA clot in this patient. The left set of images shows a very small infarct core in pink and calculates the volume at 1 ml. The right set of images shows a large penumbra in green which is the tissue at risk to completely infarct if the clot is not dissolved either with IV tPA or catheter based clot retrieval.

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Advanced Medical Imaging Consultants, PC

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