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ADVANCED MEDICAL IMAGING CONSULTANTS, PC

Common and Uncommon Images for Plastic Surgery and Soft Tissue Implants

By Michael Rogan, MD

More than 17 million cosmetic procedures were performed in the United States in 2016, according to the American Society of Plastic Surgeons (1). Because these procedures are becoming more common, it is helpful to be able to recognize findings of both the normal post-operative imaging appearance, as well as imaging findings representing complications. Complications of plastic surgery, no matter the type or location of the procedure, can generally be categorized as seroma, hematoma, infection, migration, vessel or nerve compression, fibrosis, foreign body reaction, and rupture or breakdown of the implant. In this article, I will describe the radiology findings for abdominoplasty, liposuction, autologous fat grafting, body contouring with silicone implants, subdermal implants for decorative purposes, and soft tissue fillers.

Abdominoplasty, also called “tummy tuck” is performed for reasons that include body fat disproportion, abdominal skin redundancy, musculofascial laxity, weight loss with or without bariatric surgery, and diastasis recti secondary to pregnancy. The earliest procedure was performed in the 1890’s. (1) The modern technique consists of an incision from hip to hip, subcutaneous release of the umbilicus, dissection of the soft tissues along the rectus sheath superior to the costal margin, midline muscle plication, and resection of the redundant skin. Typical normal postoperative imaging findings are linear subcutaneous fat stranding along the anterior and posterior abdominal wall and midline inward protrusion of the rectus abdominal muscles from the rectus muscle plication. (Figure 1) Complications include seromas and abscess. (Figure 2)

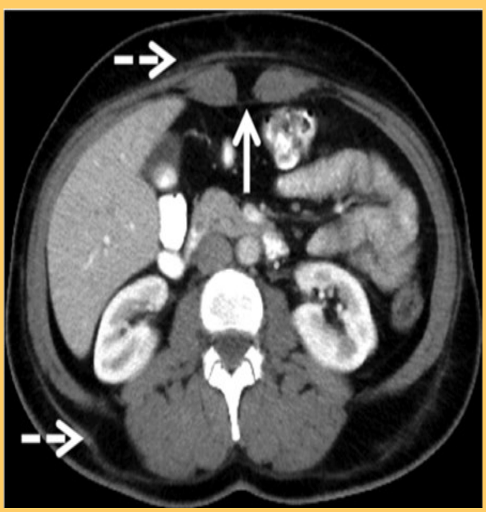


Figure 1. Typical postoperative appearance after lipoabdominoplasty in a 42 y/o woman. Axial contrast-enhanced CT image of the abdomen shows linear subcutaneous fat stranding along the anterior and posterior abdominal wall, which represents the cannula tracks from the liposuction (dashed arrows), and characteristic midline inward protrusion of the rectus abdominus muscles (solid arrow) from the rectus muscle plication performed during abdominoplasty.

Liposuction began in the 1970s and was revolutionized by Illouz in the 1980s. In 1985, Dr. Jeffrey Klein, a California Dermatologist, inveted the “tumescent technique” for liposuction, further revolutionizing liposuction surgery. His “tumnescent technique” allowed patients to have liposucition performed totally by local anesthesia using smaller cannulas. This technique allowed patients to have liposuction without the fear of excessive bleeding and undesirable skin depressions. The techniques

Figure 2. Seroma 3 weeks after abdominoplasty. Sagittal contrast-enhanced CT image of the midline of the abdomen and pelvis. There is a well-circumscribed homogeneous fluid collection (solid arrow) within the deep subcutaneous soft tissues compatible with a postoperative seroma. Typical inward protrusion of the rectus muscles and surgical clips (dashed arrows) are also seen.

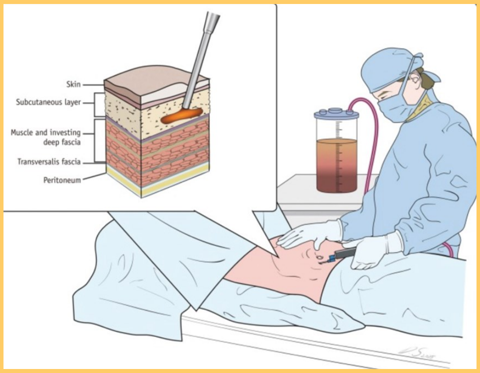


Figure 3: Illustration of liposuction surgery. Blunt cannula is inserted through small incisions to aspirate fat from subcutaneous layer. Aspirated fat is transferred to suction pump through transparent tube.

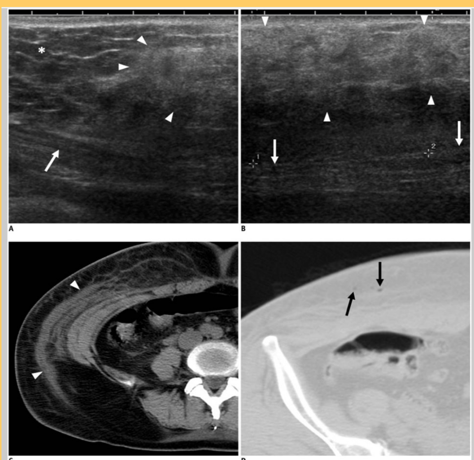


Figure 4: 53-year-old woman who underwent liposuction 3 days previously. A,B. Ultrasound demonstrates heterogeneous hyperechoic area (arrowheads) compared with adjacent normal fat (asterisk) in abdominal wall. C. Non-contrast CT demonstrates infiltrative lesion with fluid collection or lymphedema in subcutaneous area (arrowheads). D. Subcutaneous emphysema (arrows) in subcutaneous layer.

consists of inserting blunt cannulas through small access incisions after the injection of anesthetic into the fat tissue, and then aspirating fat from the deep subcutaneous layers. (2) (Figure 3 and 4) The regions often targeted are: posterior upper part of the arm, lateral chest wall, anterior abdomen, anterior and lateral pelvis, lateral and inner parts of the thigh, inferior buttock, inner part of the knee, and inner part of the calf. (1). Wound infection is the second most common complication (1%), behind contour deformity (9%). Other complications to be aware of include hematoma and seroma, which occur secondary to injuries of small perforating vessels and lymphatics.

Autologous fat grafting is a procedure where fat is harvested from one site where removal is aesthetically desired, such as the abdomen or thighs, and transferred to another area in the same patient for augmentation, commonly the buttock or breast. Other sites include facial rejuvenation, treatment for facial lipoatrophy, and hand rejuvenation. Fat grafting has increased 40% since 2007. The most common complications after fat grafting are seroma, undercorrection, infection, asymmetry, sciataglia, and fat necrosis. (Figure 5).

Body contouring with silicone implants was first described in 1991 by Novak, and is attributed to the cultural emphasis on fitness and bodybuilding during the 1980s. (1) Body contouring with silicone implants can be performed in various anatomic locations, such as the pectoralis, calf, gluteal, shoulder, or upper arm musculature. (Figure 6). Compare figure 6 of a normal calf implant, to figure 7 that shows a calf implant that is surrounded by a large amount of peri-implant fluid and free-floating debris.

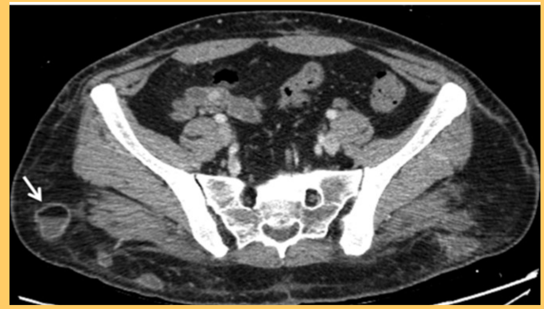


Figure 5. Abdominoplasty and gluteal fat injections, complicated by abscess. Axial contrast-enhanced CT image of the pelvis shows a peripherally enhancing collection in the right gluteal subcutaneous fat containing a fat-fluid level (arrow), a finding that represents a fat-pus level on the basis of the patient's history of fat injection complicated by abscess. Linear subcutaneous stranding in the anterior and posterior pelvic walls represents postsurgical changes of abdominoplasty and liposuction.

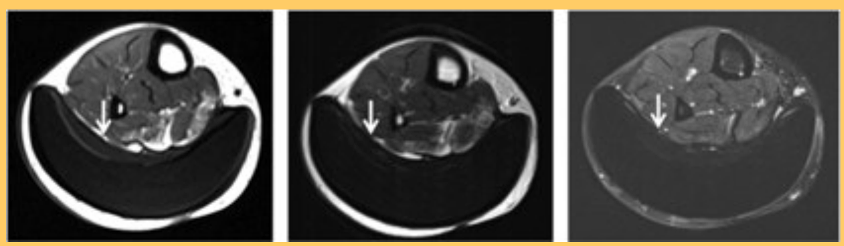
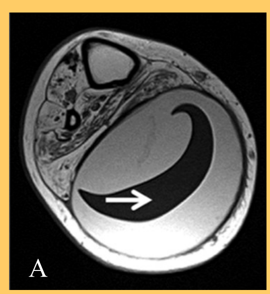


Figure 6: Normal appearance of sloid silicone calf implant. Calf implant has a smooth surface contour, without irregularity of fragmentation.



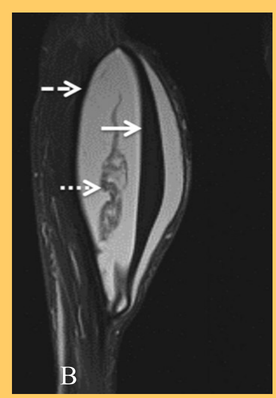


Figure 7: Calf reconstruction with solid silicone calf implant complicated by implant breakdown. Axial T1-weighted (A) and coronal T2-weighted fat-suppressed (B) MR images show a T1-and T2-hypointense subfascial solid silicone implant (solid arrow in A and B) surrounded by a large amount of peri-implant fluid (dashed arrow in B) containing hypointense free-floating debris that represents a solid silicone fragment (dotted arrow in B).

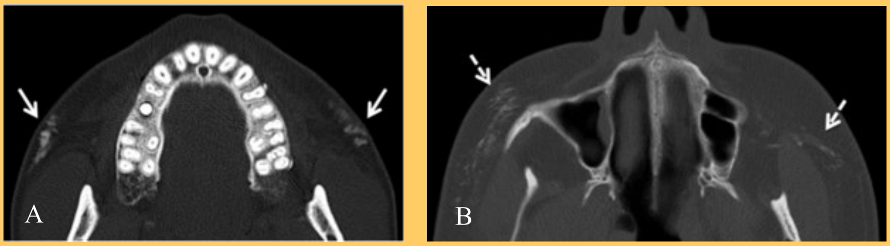


Figure 8: CT imaging appearances of calcium hydroxylapatite facial filler injection. (A) Axial maxillofacial CT image shows grouped rounded course foci (arrows) in buccal subcutaneous fat bilaterally, with mild surrounding fat stranding. (B) Axial maxillofacial CT image shows faint wispy linear hyperattenuation (arrows) in the malar subcutaneous fat bilaterally.

Smaller implants can also be placed for facial augmentation of the nose, cheek, and chin. The most common complication is a seroma, which can be seen in 21% of calf implants. (1) Other complications include implant extrusion and underisable visibility or palpability of the implant contour, hematoma, infection, would dehiscence, neurovascular injury, implant rupture, implant leakage, and capsular contraction.

Soft tissue fillers have rapidly increased in popularity in the past decade, increasing 298% since 2000. Filler agents can be used anywhere in the body for soft-tissue augmentation and wrinkle removal. The most common sites are the face and hands. Early complications occur in the first few weeks after the procedure include overcorrection, hematom, and transient erythema and/or edema. Late complications occur more than 6 months later, and include foreign body granuloma formation, infection, and compound migration. (Figure 8)

Subdermal implants for decorative purposes or sensory augmentation are placed by individuals themselves or by “body modification artists.” Varying in shape and design, artistic subdermal implants can be visible at the skin surface or indentation of the skin. Subdermal magnetic finger implants extend sensory perception by affording a sense of vibration, tingling, or buzzing when in the presence of external magnetic fields. These implants are magnets that are disks about 3 mm in diameter and 0.7 mm thick, coated in silicone to prevent rejectuion, and usualoly placed in the fourth or fifth digit of the non-dominant hand. (Figure 9) Placed at home by unlicensed practitioners with a small scalpel and sutures, complications include skin necrosis, implant extrusion, fibrosis, migration, rotation, and implant breakdown.

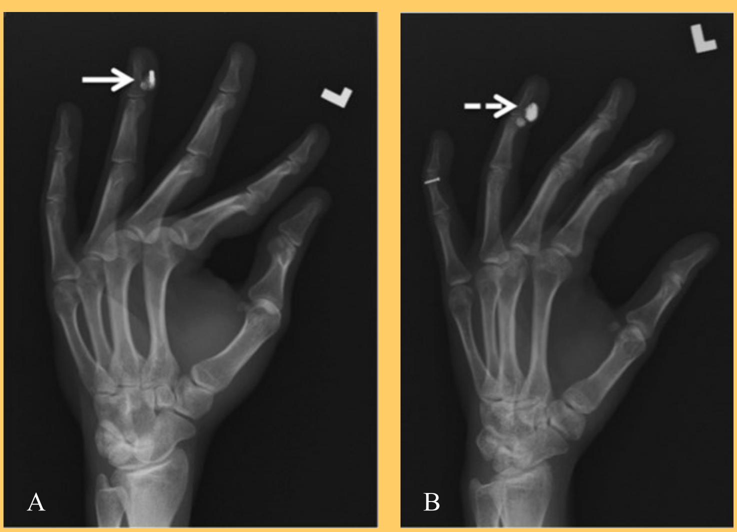


Figure 9: Subdermal magnetic finger implants, complicated by implant breakdown, in a young couple. (A) Left hand radiograph of a 29-year-old shows a discoid object within the soft tissues overlying the fourth distal phalanx. Fragmentation and irregularity along its dorsal margin demonstrate implant breakdown. (B) Left hand radiograph of the 20-year-old partner shows similar findings with loss the smooth margins of the disk and fragmentation of the magnet.

Cosmetic procedures are increasingly common, with procedures and implants placed for purely cosmetic reasons in healthy individuals, and also for patients who need reconstruction after cancer or chronic illnesses. Hopefully after reading this article, the normal imaging appearance as well as complications from procedure such as abdominoplasty, liposuction, autologous fat grafting, body contouring with silicone implants, subdermal implants, and soft tissue fillers will help the reader confidently recognize these findings.

Refences:

1. Lin, Dana F., Wong, Tony T., Ciavarra, Gina A., Kazam, Jonathan K. Adventures and Misadventures in Plastic Surgery and Soft Tissue Implants. Radiographics 2017;37:2145-2163.

2. Je Sung You, Yong Eun Chung, Song-Ee Baek, Sung Phil Chung, Myeong-Jin Kim. Imaging Findings of Liposuction with an Emphasis on Postsurgical Complication. Korean J Radiol. 2015 Nov-Dec; 16(6): 1197-1206.

Michael Rogan, MD

Pre and Post TIPS Evaluation: What is Normal and What We Need to Know

By Kenneth Cicuto, MD

Sonography is a valuable tool for evaluating the liver in patients with diffuse liver disease and portal hypertension. The anatomy and morphology of the vasculature and parenchyma in additional to functional information such as vascular patency, flow direction, and flow patterns are critical pre-procedural information.

These imaging capabilities make US a useful imaging modality in the evaluation of patients before, during, and after transjugular intrahepatic portosystemic shunt (TIPS). (Figure 1)

The majority of TIPS patients have suffered long term cirrhosis. This underlying fibrotic condition of the liver often results in a heterogeneous, coarse, and echogenic liver leading to an inherently difficult exam. Several technical modifications can be employed to optimize imaging of the hepatic vasculature in patients with cirrhosis. In general, Doppler interrogation of the hepatic vasculature is optimized by using a transducer with the highest possible frequency that will still provide adequate tissue penetration. Since the cirrhotic liver attenuates the sound beam, adequate tissue penetration often requires use of a low-frequency transducer (often a 2-MHz transducer). Optimal transducer frequency varies with each patient, and it may be necessary to vary the transducer used to optimize imaging in any given patient. In addition, the highest allowable power output should be used when interrogating the hepatic vessels. Other techniques that may improve the sensitivity for the detection of blood flow include increasing the gain to maximize signal amplification, lowering the wall-filter settings, and the use of a lower-pulse repetition frequency and scale. (Figure 2) Finally, detection of blood flow by means of Doppler sonography is critically affected by the angle of insonation. Lower scan angles produce larger Doppler frequency shifts. Scan angles less than 60° are generally required for accurate calculations of flow velocities. The interrogation can require a multitude of angles and different respiratory phases.

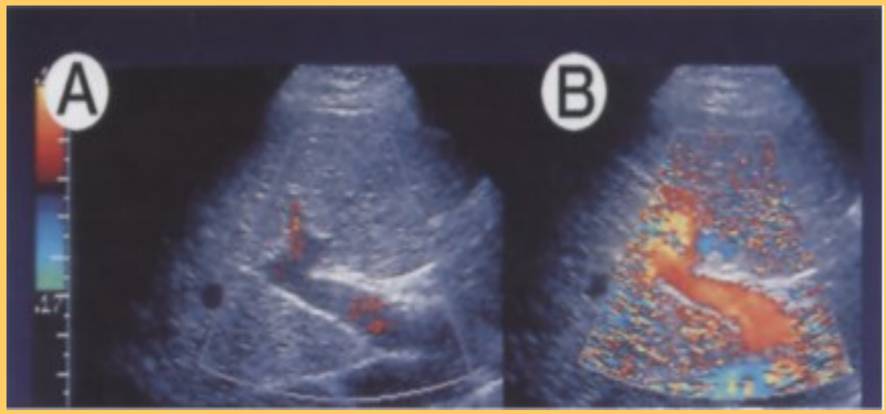


Figure 2: Increasing signal gain helps rule out false portal vein thrombosis.

Pre –Op Evaluation

Preoperative evaluation entails detailed vascular exam, ancillary baseline changes from portal hypertension and verification there are no contraindication to TIPS.

Firstly, document sequelae of portal hypertension include ascites, right pleural effusion, splenomegaly, or any visible portosystemic collateral vessels. Abnormal parenchymal findings detected on sonography that would preclude or postpone TIPS include polycystic liver disease, unsuspected biliary dilation or new hepatic mass (hepatocellular carcinoma). (Figure 3)

The key component for the interventionalist is the anatomy of the portal vein. Verification of portal vein patency, directional flow and baseline velocity are critical. Rule out any non-occlusive thrombus which could change surgical approach. Note if there is bifurcation of the main portal outside of the liver parenchyma. Demonstrate patency and size of the hepatic vein.

Finally, the overall attenuation of the cirrhotic liver during this exam can give your IR an idea of the utility of intravascular ultrasound (ICE catheter) intra-procedurally.

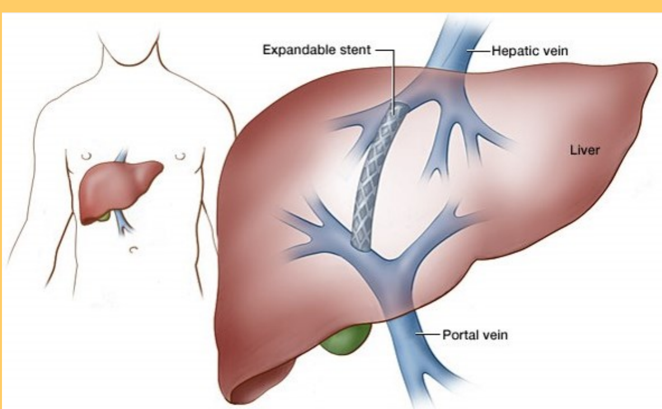


Figure 1

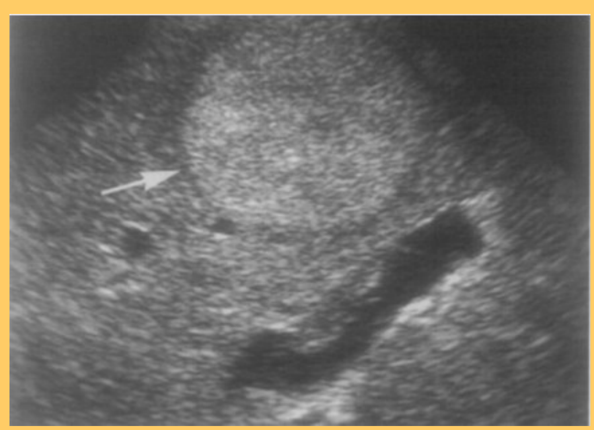


Figure 3: Incidental HCC found on pre-TIPS evaluation.

Post-Op Evaluation:

Typically, the first TIPS evaluation occurs 1-2 days after placement. Previously, air trapped in the stent precluded visualization until about 2 weeks but this is typically no longer the case with newer generation double lined PTFE stents (Viatorr).

Prior to evaluating the stent and vasculature, look for possible early post op complications. These can include subcapsular/ intraparenchymal hematoma, hepatic infarct, biloma, hemobilia or hemoperitoneum. (Figure 4)

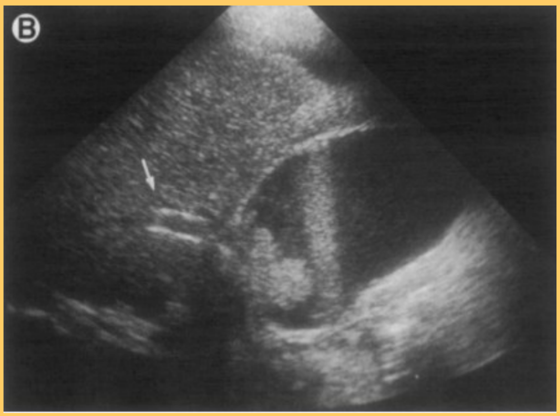


Figure 4: Echogenic blood within the gallbladder from hemobilia

Vascular exam:

This is most critical component as it will serve to signal any TIPS dysfunction and trigger reintervention to prevent clinical complications such as variceal bleed, ascites, etc. The exam includes three basic components: identification of flow within the shunt, maximum velocity at the leading, middle and trailing aspect of the stent, and flow direction within the intrahepatic portal vein branches. Other ancillary findings of interest include peak flow velocity in the main portal vein, patency/direction of the splenic vein and patency of any known collaterals.

First evaluate the stent with gray scale imaging. The stent should curve without any kinks. The stent should be uniform in caliber and be positioned "squarely" with the interface with the hepatic and portal veins. (Figure 5) Look for any echogenic clot at the tips of the stent which can occur during vascular or biliary injury with placement.

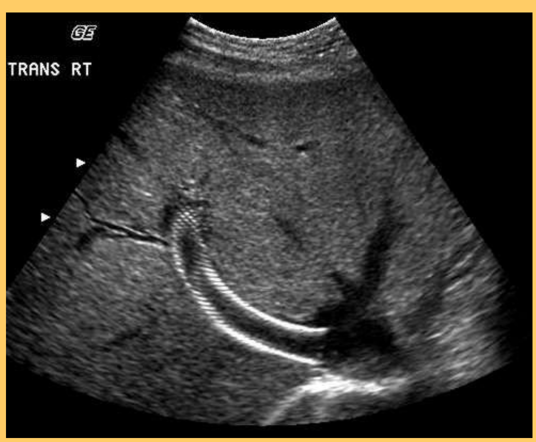


Figure 5: Smooth curve with "square" interface.

Verify patency and hepatopedal flow of the main portal vein. Velocity of main portal should be > 30cm/sec. Decreased velocity is an indication of dysfunction. Identify direction of flow in the opposite portal branch (typically left). Remember the hepatofugal flow can be normal flowing TIPS as it is taking the path of least resistance. Compare to priors as directional flow changes in the non-involved portal branches are key indicators of disfunction.

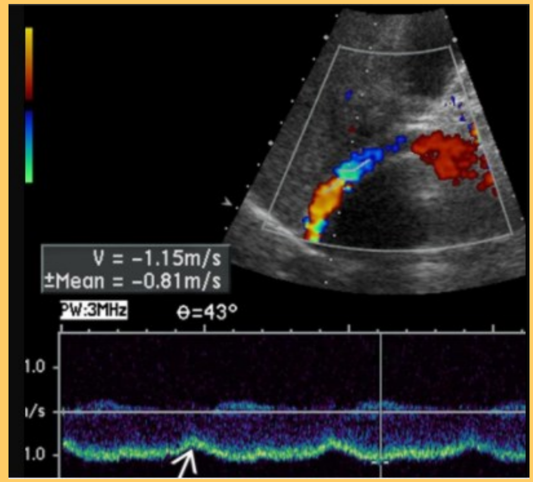


Figure 6: Normal velocity with mildly undulating waveform.

Within the shunt, flow should be mildly turbulent and continuous. Slightly respiratory variation and pulsatility is normal. Normal peak velocities are typically between 90 -200cm/sec. (Figure 6) There should be similar velocities throughout; there should not be a > 50cm/sec variation at any given point or study-to-study comparison. Focal aliasing and velocities changes are specific finding for dysfunction.

The most common presentation of TIPS malfunction is worsening clinical ascites or bleed from the increasing portal pressure so DON'T forget to ask the patient sometime during the exam. Identifying early dysfunction will trigger angiography +/- reintervention. In many of these patients, this can prevent future variceal bleeds and save a life so thanks for all your great work!!!

If there are any concerns or questions during these exams, please reach out to me or any of your friendly neighbor interventional radiologists. Happy winter and pray for snow!

Kenneth Cicuto, MD

Hysterosalpingography

By Amy Hayes, MD

Hysterosalpingography (HSG) has become a commonly performed exam with the growth of reproductive medicine fertility work ups and the increased use of tubal closure devices to prevent pregnancy.

The primary role of HSG is to evaluate the patency of fallopian tubes.

And while ultrasound is typically used to evaluate the endometrium, HSG can provide information about the endometrial cavity including size, shape and endometrial abnormalities.

Indications

-infertility
-multiple spontaneous abortions
-postoperative evaluation post tubal ligation or tubal occlusion (Essure device)
-postoperative evaluation post tubal ligation reversal
-postoperative evaluation prior to myomectomy

AMIC Pre-Procedure Protocol

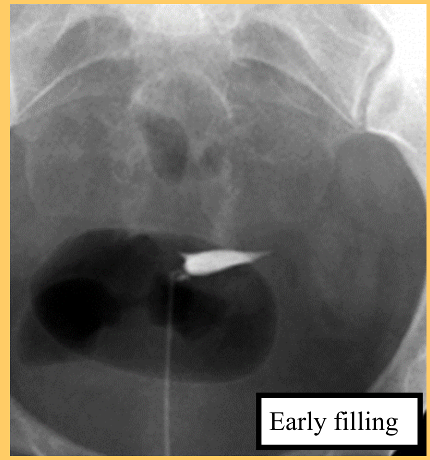
Patient Pre/Instructions

- Schedule for 6-12th day of menstrual cycle (day 1 being the first day of menstrual bleeding).
- Patient should be instructed to abstain from sexual intercourse from the time menstrual bleeding ends until the day of the exam to avoid potential pregnancy.
- If patient has irregular menstrual cycles or there is a possibility of pregnancy, a serum pregnancy test must be performed prior to the exam.
- Because patients may experience cramping during the examination, they are advised to take whatever over-the-counter medication they normally take for aches and pains (other than Aspirin) 1-hour prior to the procedure.

Technique:

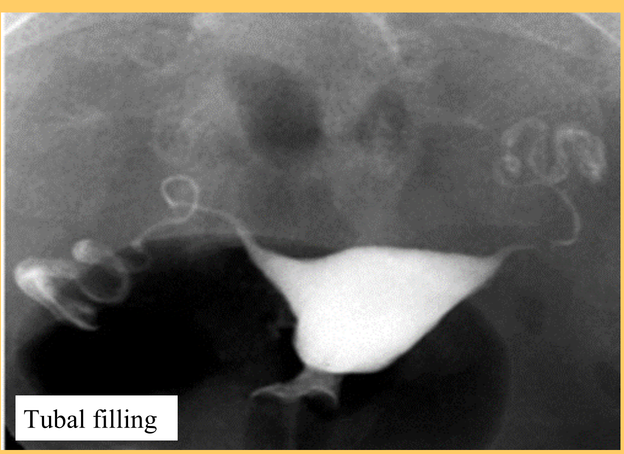
- Cervix is visualized and cleansed with Betadine
- 5Fr or 7 Fr hysterosalpingography catheter inserted into the cervix and balloon inflated. Water soluble contrast (Isovue 300) is injected. At least 5 images should be obtained:
    1. Scout image after catheter placement but before contrast has been injected
    2. During early filling of the uterus. Small filling defects best seen on this image
    3. Endometrial cavity fully distended
    4. Filling of fallopian tubes
    5. Free spill from the fallopian tubes

Images from a normal HSG are shown here:

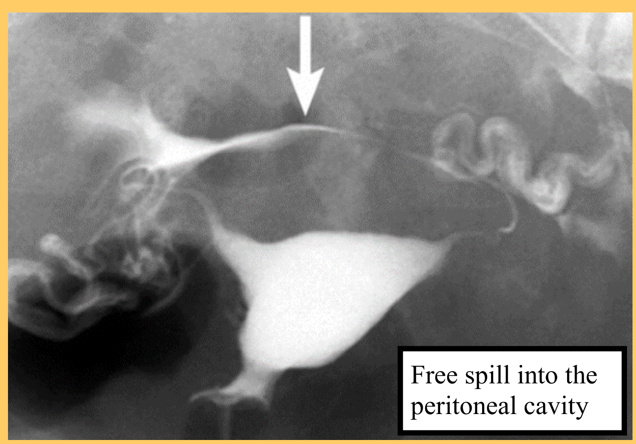


Early filling

Fully distended-superior margin of the endometrial cavity is con-



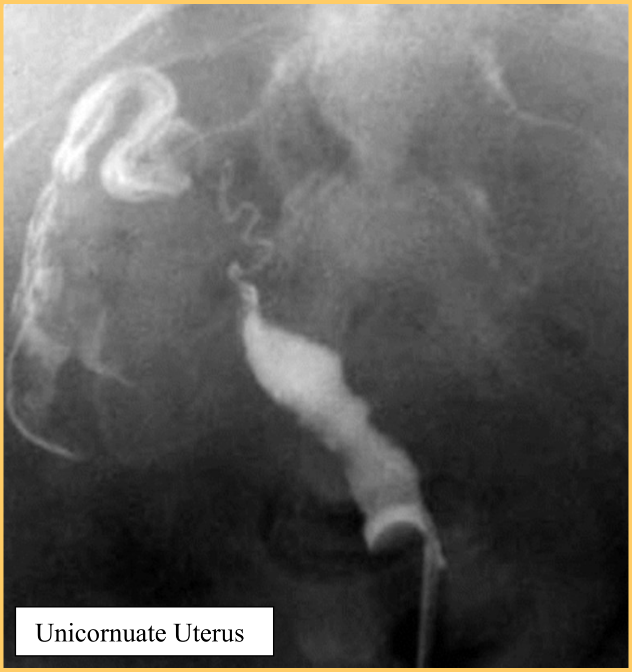
Tubal filling



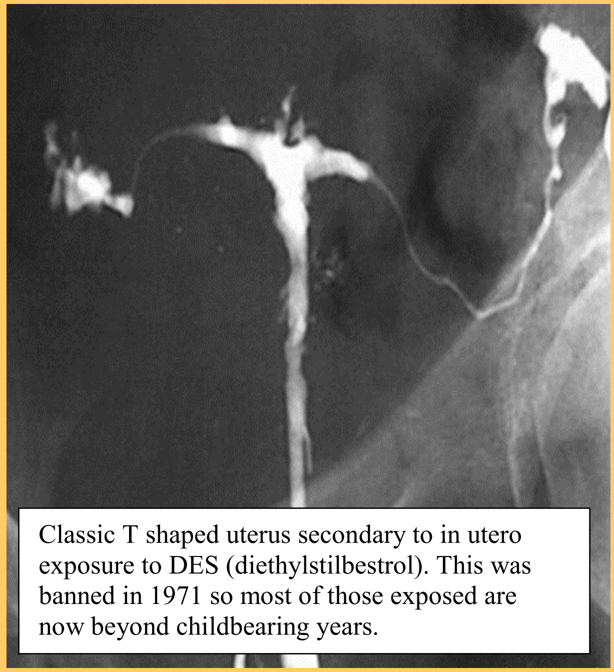
Free spill into the peritoneal cavity

Uterine Anomalies:

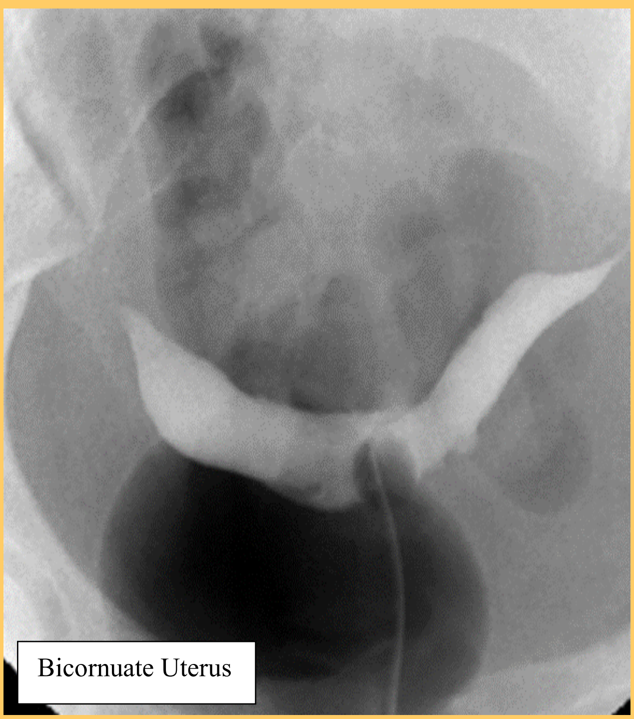
Due to abnormal fusion of the mullarian ducts during early (6-12 weeks) gestation.



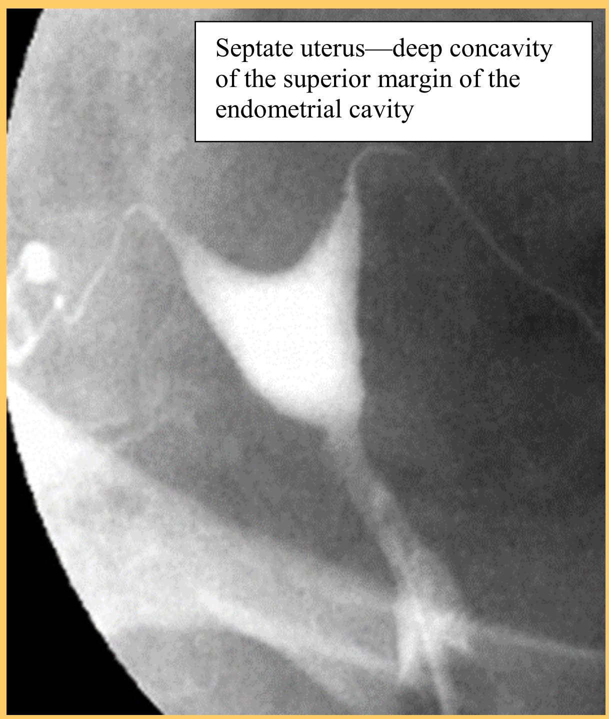
Unicornuate Uterus



Classic T shaped uterus secondary to in utero exposure to DES (diethylstilbestrol). This was banned in 1971 so most of those exposed are now beyond childbearing years.



Bicornuate Uterus

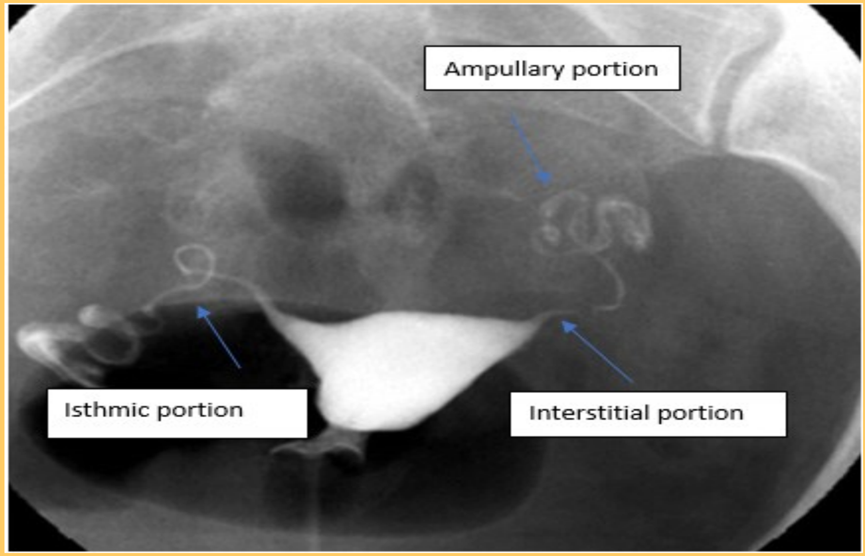


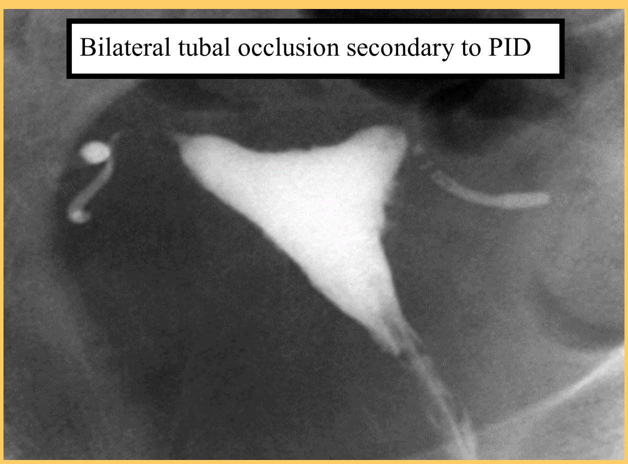
Septate uterus—deep concavity of the superior margin of the endometrial cavity

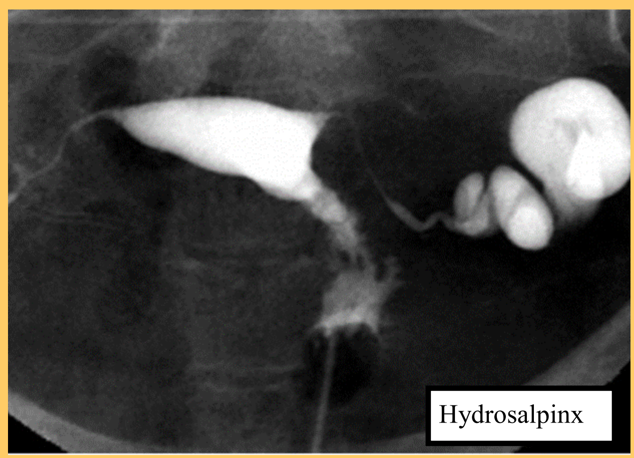
Tubal Abnormalities:

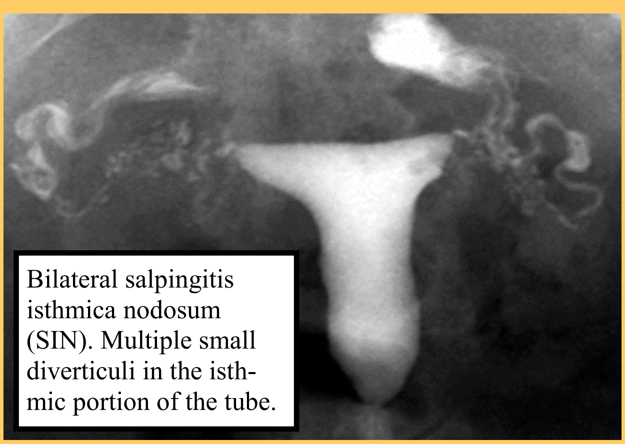
Normal fallopian tubes are 10-12 cm in length and course along the superior aspect of the broad ligament. There are three segments of the fallopian tube. The isthmic portion is the segment traversing the muscular wall of the uterus. The isthmic portion is the long thin middle segment. The ampullary potion is the widened portion near the ovary. At HSG they should appear as thin, smooth lines that widen in the ampullary portion.

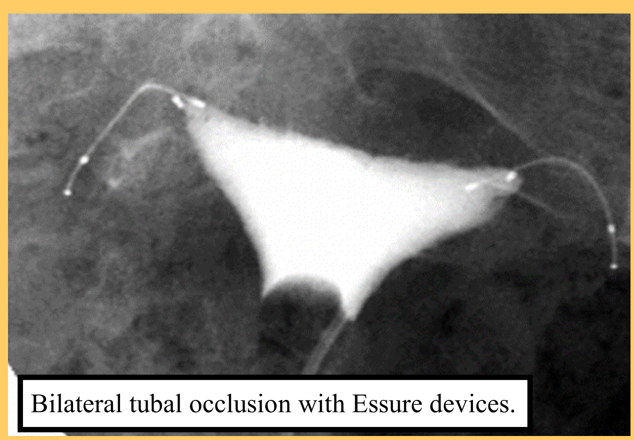
The most common cause of tubal occlusion is pelvic inflammatory disease (PID). Salpingitis isthmica nodosum (SIN) causes multiple diverticuli in the tube and is of unknown cause. It can be associated with infertility. Tubal polyps are rare. Hydrosalpinx is a dilated, fluid filled tube secondary to a distal occlusion. This can be caused by infection or endometriosis.



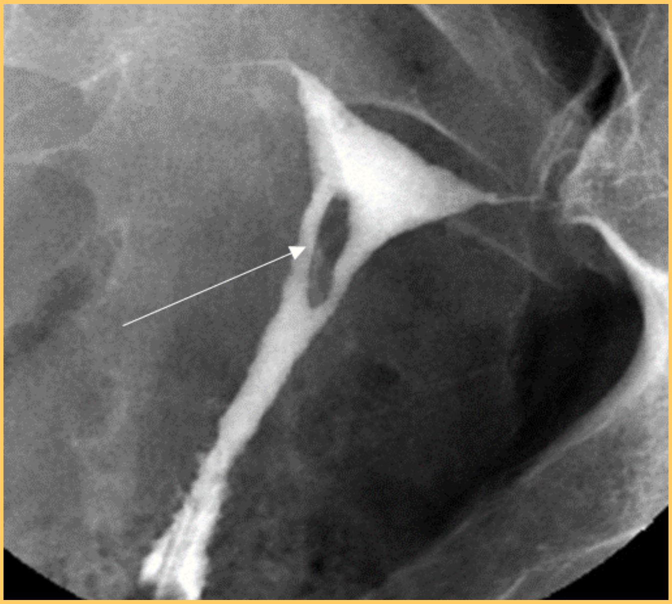

Bilateral tubal occlusion secondary to PID


Hydrosalpinx

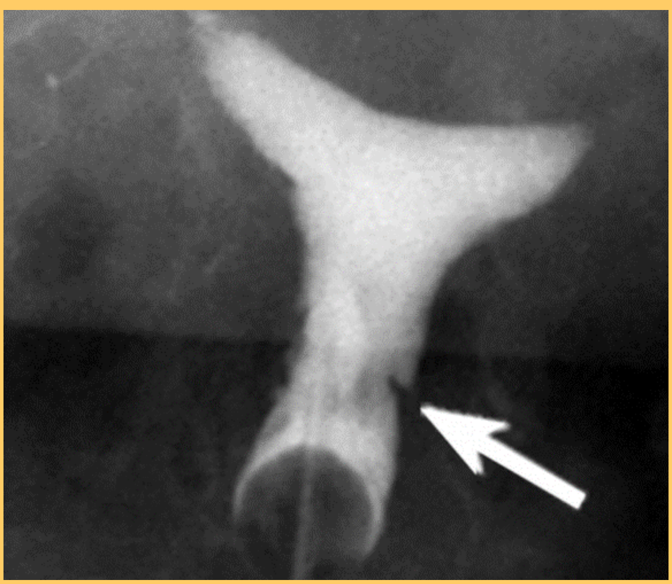

Bilateral salpingitis isthmica nodosum (SIN). Multiple small diverticuli in the isthmic portion of the tube.

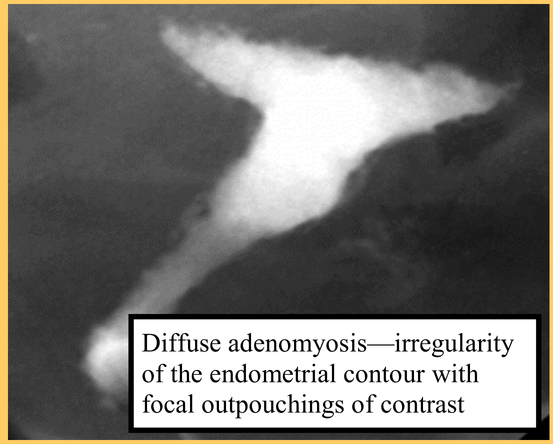

Bilateral tubal occlusion with Essure devices.

Luminal Filling Defects

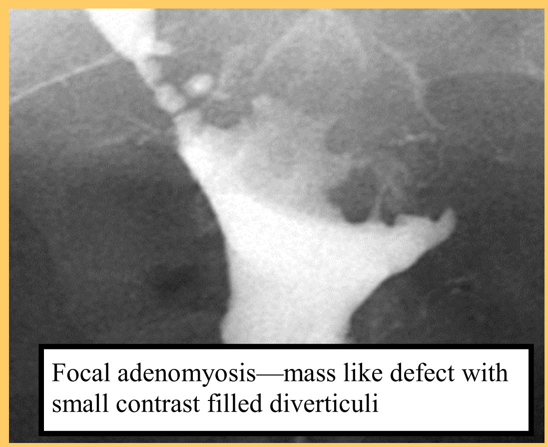


Synechiae are intrauterine adhesions due to scarring most often secondary to prior curettage.

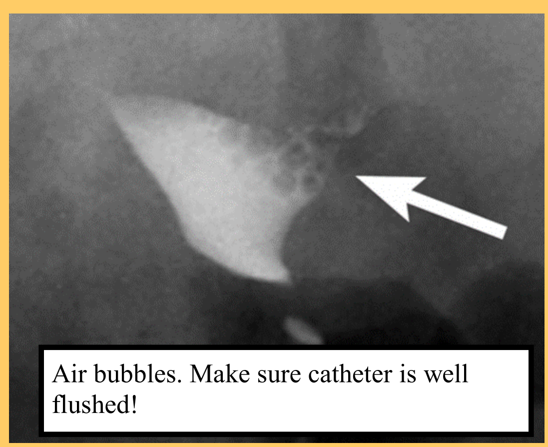




Diffuse adenomyosis—irregularity of the endometrial contour with focal outpouchings of contrast

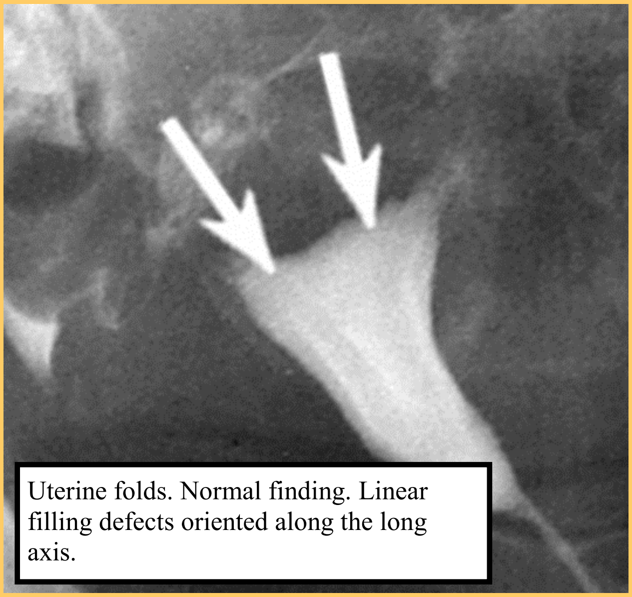


Focal adenomyosis—mass like defect with small contrast filled diverticuli

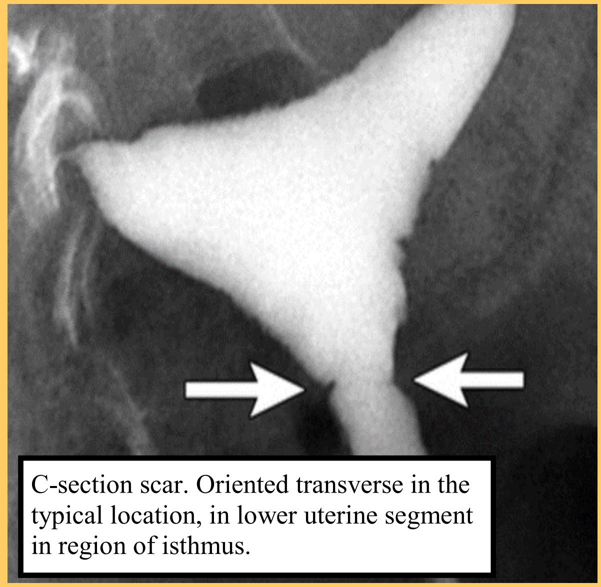


Air bubbles. Make sure catheter is well flushed!

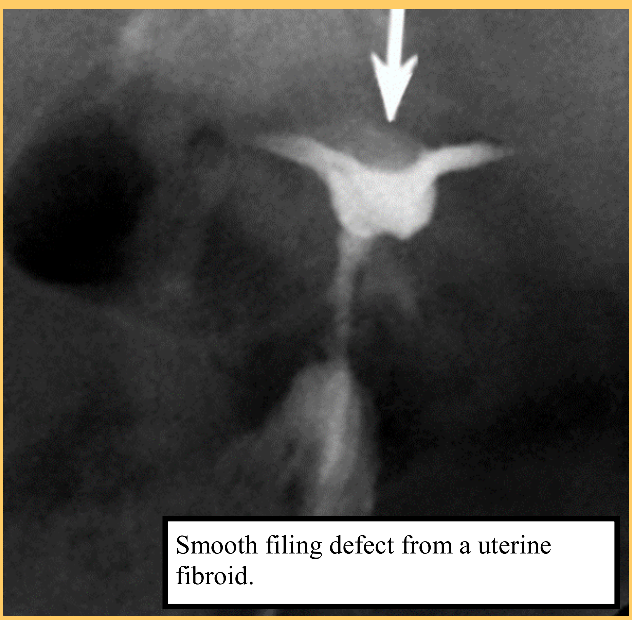
HYSTEROSALPINGOGRAPHY CONT...



Uterine folds. Normal finding. Linear filling defects oriented along the long axis.



C-section scar. Oriented transverse in the typical location, in lower uterine segment in region of isthmus.



Smooth filing defect from a uterine fibroid.

Amy Hayes, MD

CT Protocols and the ALARA Principle for Minimizing Radiation Exposure

By Nicholas Statkus, MD

Many CT protocols are well established regarding what acquisitions are needed to try to answer the question at hand. The need to give, or not give, contrast to image the area of interest hinges on what specific information is needed. Administering contrast allows for identification of structural abnormalities in some areas of the body which may not be seen without contrast. For example a small hepatic metastasis will be much better seen with contrast compared to a non-contrast study. A hepatic laceration in the trauma setting will be visible on a contrast enhanced and may be invisible on a non-contrast study.

Not all diagnoses require the usage of contrast with CT. For example if there is concern for a obstructive ureteral calculus a **non-contrast** abdomen and pelvis CT is performed. The dense calculus will be visible in the ureter on a non-contrast CT. For head trauma a **non-contrast** head CT is performed. Any intracranial hemorrhage will be visible on the non-contrast study and in fact administering contrast could make it difficult to see some intracranial hemorrhage as venous sinus and cortical vein enhancement may blend with the hemorrhage and make it difficult to actually see.

Other CT protocols call for just contrast enhanced images. As discussed above a trauma patient with injury to the body requiring imaging should get a **contrast enhanced** chest, abdomen, and pelvis CT (not a non-contrast exam) unless there are contraindications to the patient getting contrast (such as acute renal failure).

Then there are protocols that call for both non-contrast and contrast-enhanced acquisitions. A renal mass protocol has pre- and post-contrast acquisitions. These are needed to evaluate for contrast enhancement of the lesion in question. An ROI (region of interest) is put over the lesion on the non-contrast acquisition and on the nephrographic phase acquisition. If the lesion in question has an increase in density of at least 20 Hounsfield Units this suggests the lesion is taking up the contrast and is solid. A benign proteinaceous or hemorrhagic cyst will be dense on the baseline non-contrast CT and should have similar Hounsfield Unit measurements on the pre- and post-contrast acquisitions.

The last point I want to make brings me to the reason I wanted to discuss this topic which is the usage of pre- and post-contrast CT imaging when only one of the acquisitions is needed. There are two studies in particular to discuss which get ordered not very often, but often enough to where I feel it is worth talking about. I am referring to neck CT without and with contrast and chest CT without and with contrast. Of the two the neck CT without and with contrast gets ordered with more frequency.

When the clinical question is neck mass or abscess the only thing which should be performed is a post-contrast acquisition. The contrast enhanced acquisition will identify any mass, abnormal lymph nodes or abscess. If the two acquisitions (non-contrast and contrast-enhanced) are ordered and performed the non-contrast acquisition is redundant and adds minimal value to the study. The non-contrast study **increases cost** to the patient and additionally is **unnecessary radiation exposure** to the patient. There are a few unique and infrequent situations where a pre- and post-contrast neck CT may be helpful. For example in the setting of a post cervical spine fusion patient where the concern may be for a hematoma in the neck soft tissues both the non-contrast and post-contrast images may be helpful to differentiate between a hematoma or abscess.

The majority of neck CTs without and with contrast I see ordered and performed are for "rule-out neck mass" and in these cases the non-contrast neck CT component is unnecessary. I would encourage you to call the radiologist to discuss the protocol if you see these ordered. I would likely change the protocol to a post-contrast acquisition only unless there were compelling reasons to use the non-contrast acquisition as well. It is in the patient's best interest in most of these cases to just obtain a contrast enhanced scan.

There is a specific neck CT protocol which does call for non-contrast enhanced imaging followed by multi-phase post contrast acquisitions which is the parathyroid nodule protocol and this protocol is not part of this discussion. If there is concern for a parathyroid nodule the parathyroid protocol is the one to use.

The second study I mentioned is the chest CT without and with contrast usually ordered on outpatients. This gets ordered less frequently then the neck CT without and with contrast but I have seen these occasionally ordered and performed as well. Just like with the neck a **post-contrast** chest CT to evaluate for a lung mass/nodule/lymphadenopathy, or for typical diagnoses such as a pulmonary infection, gives you all the information you need. Obtaining a non-contrast acquisition, in addition to the contrast enhanced CT, adds no benefit to the study and increases patient cost and radiation. There are definitely some situations which require pre- and post-contrast chest CT. Specifically aortic dissection or penetrating atherosclerotic ulceration of the aorta are both diagnoses where the non-contrast acquisition does give some meaningful information to the study. If the clinician orders a **non-emergent** routine chest CT without and with contrast the only acquisition that should be performed is the post-contrast acquisition. Again this is in the patient's best interest and I would encourage you to call the radiologist to discuss the proper acquisition to obtain if you see a chest CT without and with contrast study ordered on a routine outpatient.

When neck and chest CTs are ordered both without and with contrast I think the reasoning behind ordering both of the acquisitions is that the ordering clinician thinks this is the ideal way to diagnose pathology in these areas but in reality this is not the case.

I would encourage you to call the radiologist to assist with the protocol to use if you ever see a neck or chest CT without and with contrast ordered. Imaging studies are already expensive for patients and if we can reduce this expense, especially when the additional images are unnecessary, it is for the patients benefit. Additionally as discussed with the increasing usage of CT, with multiple CTs performed on patients throughout their life, any reduction in radiation exposure is a plus. You may have heard of the principle of **ALARA** regarding radiation exposure. This stands for **as low as reasonably achievable** and this principle applies to the usage of neck and chest CTs without and without contrast when ordered inappropriately.

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