Conventional Radiology

Editors:

Kyle D. Wood, MD

Authors:

Joseph J. Crivelli, MD; J.E. “Jed” Ferguson, III, MD/PhD

Last Updated:

Friday, March 3, 2023

Summary

In many settings, conventional radiology has been supplanted by other imaging modalities including CT and MRI, given their increased specificity and sensitivity. However, conventional radiology with or without the use of intravenous or intraluminal contrast is still used for the evaluation of many urological conditions and to help facilitate surgical procedures. Herein, we review the common conventional radiographic options and their uses in urology.

Keywords

urinary tract imaging, plain film, contrast, urethrogram, pyelogram

1. Plain Film Radiography and Excretory Urography

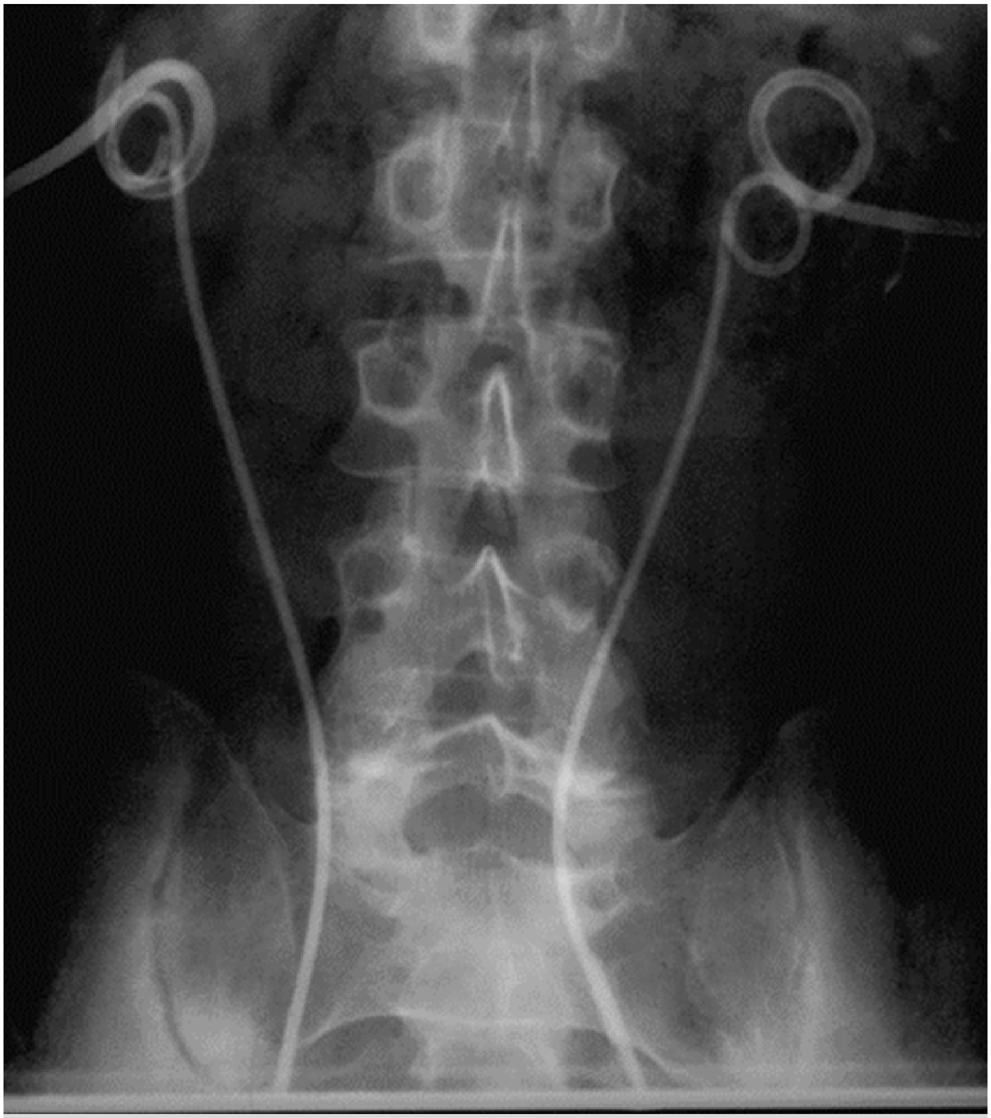

Figure 1 A plain film radiograph demonstrating the proximal position of the patient's ureteral stents and nephrostomy tubes.

Figure 2 A plain film radiograph demonstrating the limitations of this imaging modality. Bowel gas (black arrows) makes evaluation of the renal units difficult. Bony structures (white stars) can interfere with identifying calcifications.

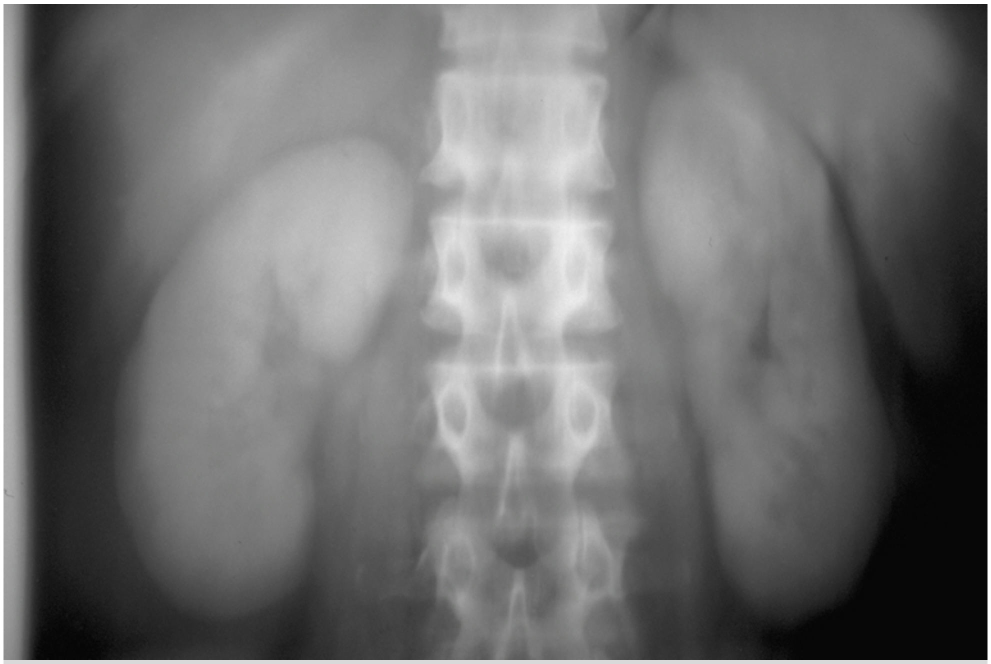

Figure 3 The nephrogenic phase is captured on this radiographic image after intravenous injection of contrast.

1.1 Abdominal Plain Film Radiography

Plain film radiographs of the abdomen and pelvis without intravenous contrast are typically obtained as a scout prior to obtaining an intravenous or intraluminal urogram, but do have a role as a single modality in certain circumstances. Radiographs can be used to assess for the presence or absence of radio-opaque **urinary calculi** before and after treatment and to evaluate the **position and integrity of urinary stents or percutaneous nephrostomy tubes** after placement (**Figure 1**). Bowel gas can obscure faintly opaque or small calculi, and therefore if there is a high clinical suspicion, then further studies are warranted (**Figure 2**).[1] While abdominal plain film has largely been replaced by CT for the evaluation of urinary calculi, it is relatively inexpensive and is associated with less radiation exposure than CT and therefore still can be a useful follow-up study in patients with radiopaque calculi, limiting radiation exposure.[2] Limitations of plain film radiography include the above mentioned issues with overlying bowel gas, but additionally, stool burden and other normal anatomic structures such as ribs and bones can make interpretation difficult. Further, given the 2D configuration, other calcifications (such as phleboliths or vascular calcifications) may be confused as calculi.

Intraoperative fluorography is also utilized to identify sacral bony landmarks, and to facilitate correct perineural placement of electrical leads during InterStim neuromodulator placement.

1.2 Iodinated Contrast: Physiologic Principles

Diagnostic evaluation of the genitourinary tract using conventional X-ray is dramatically enhanced after the instillation of intravascular or intraluminal contrast agents. The bulk of injected intravascular contrast material is excreted via glomerular filtration by the kidney and into the collecting system, following well-characterized kinetics. The vascular or corticomedullary phase appears 25-80s after injection of IV contrast. The nephrographic phase is present approximately 90s after injection. And the pyelographic or excretory phase is present as early as 3 minutes after injection (with longer times in obstructed renal units). A small fraction of contrast material does bind to serum albumin and is excreted by the liver. Patients with renal insufficiency will have a greater proportion of contrast material excreted via the biliary system (vicarious excretion). [3] For a detailed description of contrast agents and their intravenous administration, along with the associated rates of adverse events and management of these events, please see the Chapter on **Computed Tomography**.

The rates of adverse reactions to intraluminal injection of contrast agents is very low, but not zero.[4] This is likely due to intravenous exposure of intraluminally injected contrast material via pyelovenous backflow or other mechanisms. Thus, in patients with a history of severe reactions to intravenous contrast media, intraluminal contrast administration should be avoided if possible, or administered cautiously and after the administration of pre-medication.

1.3 Intravenous Urography (IVU)

Intravenous urography (IVU) was the main radiographic technique for evaluation of the upper urinary tract for decades. While it has been replaced by computed tomography urography (CTU) in many settings, urologists should be familiar with the techniques and interpretation of this diagnostic modality. IVU involves administration of intravenous contrast material followed by acquisition of multiple plain film radiographs of the abdomen and pelvis at specific time sequences.

1.3.1 Indications for IVU

1. **Gross and microscopic hematuria**: While IVU can provide evaluation of both the renal parenchyma and the collecting system, it is less sensitive and specific than CTU for the detection and characterization of renal masses and therefore is typically combined with renal ultrasound for better renal parenchymal evaluation.
2. **Upper urinary tract** surveillance for patients with bladder cancer
3. Evaluation of urinary tract anatomy and abnormalities,[5] including renal ptosis[6]
4. Evaluation of complicated **urinary tract infection**
5. Prior to renal exploration for trauma. The **AUA Urotrauma Guideline** specifies that surgeons may perform a one-shot IVP to document function of the contralateral, uninjured kidney using 2 mL/kg IV contrast and a delayed image at 10-15 minutes.[7]
6. Stone disease: IVU has largely been replaced by non-contrast CT for patients with acute renal colic. Small, faintly opaque calculi are difficult to visualize on IVU, which limits its utility. Additionally, in the setting of acute obstruction, contrast may not opacify the collecting system, limiting the ability of IVU to precisely define the location of a calculus.
7. Percutaneous access to the kidney: If retrograde instillation of contrast is not possible and ultrasonography is not available, IVU can aid in opacifying the collecting system.[8] As mentioned, contrast may not opacify the collecting system if there is high-grade obstruction.

8. Shockwave lithotripsy: IVU can be performed to target radiolucent stones.

It is important to note that for the indications above, there are usually modalities that are now preferred over IVU.

1.3.2 Technique

Prior to contrast administration, a “scout” plain film radiograph of the abdomen and pelvis is performed. This can identify radio-opaque calculi, which are often obscured with excretion of contrast material. Intravenous contrast material is then administered, and radiographs are obtained in a standard time sequence. Contrast is injected as a bolus of usually 50 to 100 milliliters. Sequential plain film radiographs during contrast excretion are then obtained including post void films to evaluate the urothelium. Images are typically obtained at 5-minute intervals.[9] The initial image captured will demonstrate the nephrogenic phase (**Figure 3**). Films are then taken at 5-minute intervals until the images are appropriate for the clinical question. **Figures 4-5** illustrate the excretory phase where contrast opacifies the collecting system and ureter.

2. Cystography and Voiding Cystourethrography (VCUG)

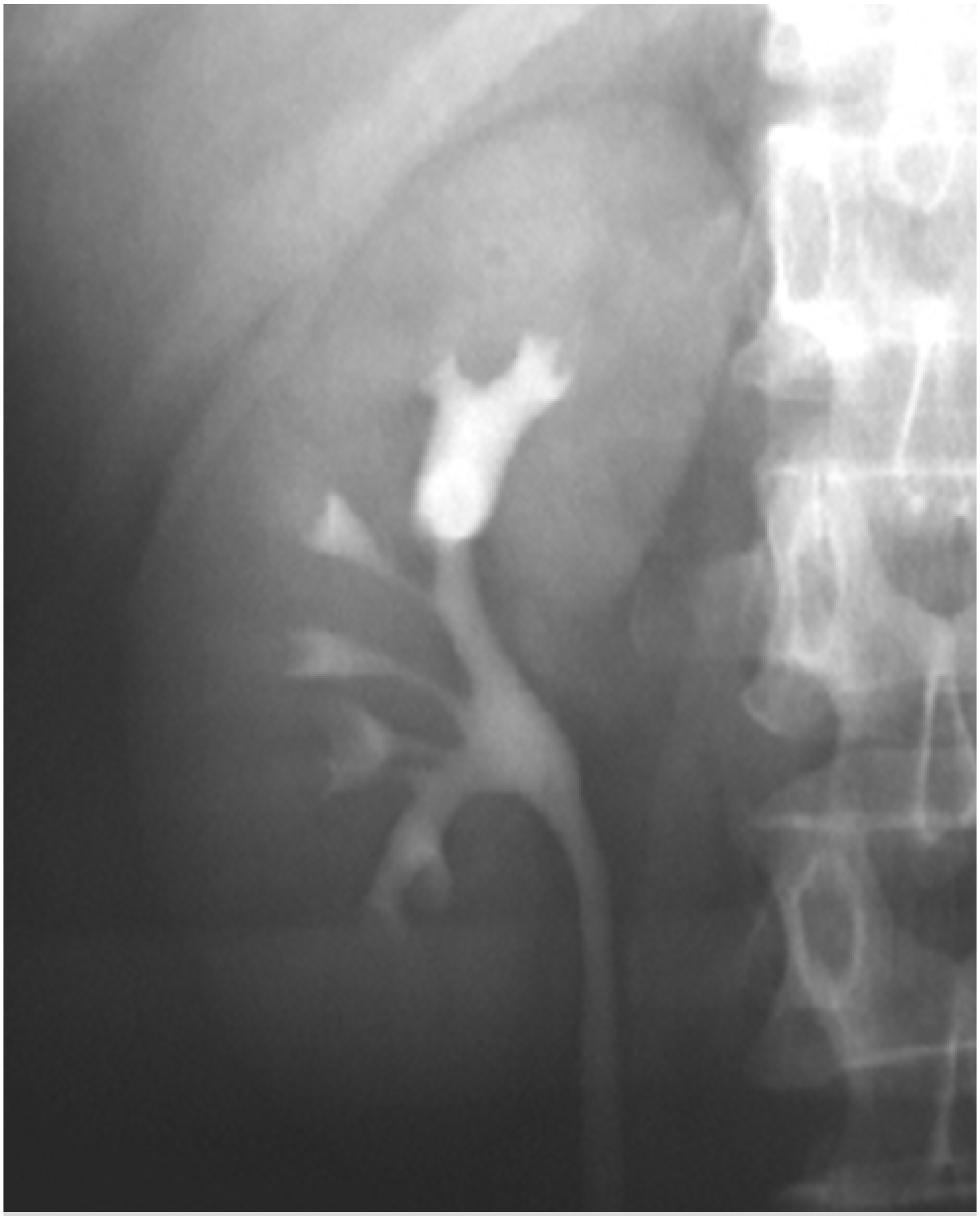

Figure 4 The excretory phase is captured on this radiographic image. The collecting system is well visualized.

Figure 5 Intravenous excretory urogram (IVU) demonstrating the collecting systems and ureters

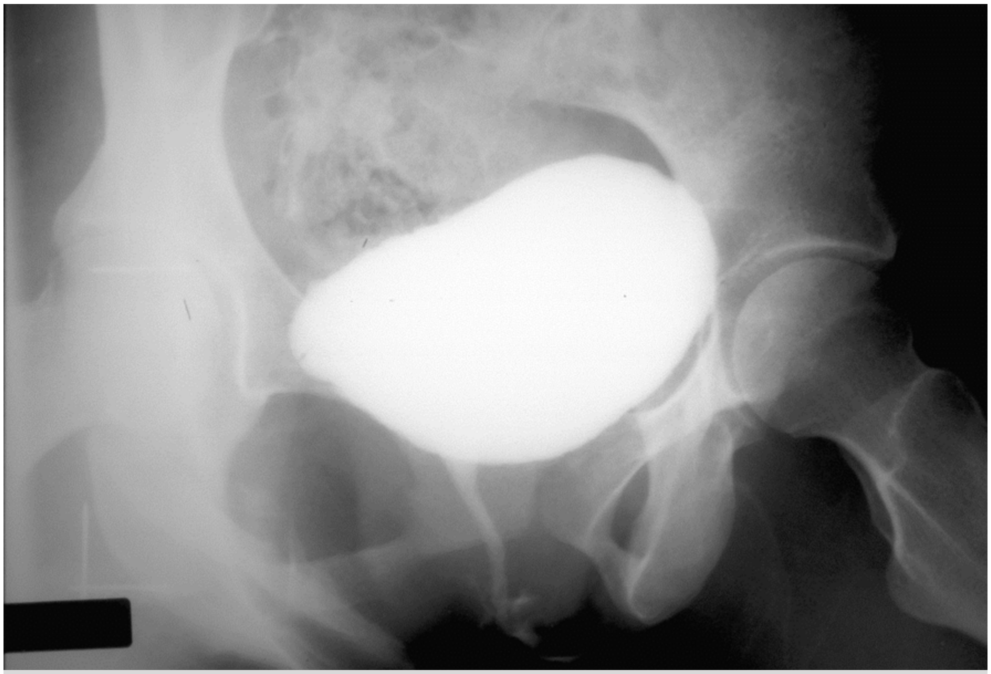

Figure 6 Voiding Cystourethrography evaluating the bladder and urethra in a female patient.

This radiographic study uses contrast media and conventional radiographs or fluoroscopy to delineate the anatomy of the bladder and urethra and associated pathology (**Figure 6**). This study is commonly used in the pediatric population to evaluate for vesicoureteral reflux and the posterior urethra in boys. It is also commonly used in adults post-surgically to verify healing after procedures such as cystorrhaphy and urethroplasty.[3]

2.1 Indications for VCUG

Pediatrics	1. Evaluate bladder anatomy 2. Evaluate bladder outlet 3. Evaluate vesicoureteral reflux 4. Evaluate urethral anatomy and pathology
Adults	1. Evaluate post-surgical repair of bladder and urethra 2. Evaluate bladder anatomy 3. Evaluate bladder outlet (obstruction) 4. Evaluate urethral anatomy

2.2 Technique

Prior to VCUG, a scout radiograph of the pelvis should be obtained. A catheter is then inserted in the bladder. VCUG can also be performed in an antegrade fashion via a suprapubic tube in patients with significant urethral pathology. A small feeding tube (5 to 8 Fr) is used in the pediatric population, whereas a Foley catheter is used in adults. The bladder is then filled with contrast via the catheter to an appropriate age-based volume **(for pediatric patients this volume in milliliters is calculated as [age in years +2] x30)**. Filling by gravity can prevent generation of excessive pressure. In adult patients, 200-400 milliliters is sufficient for the study. Low volumes may decrease sensitivity of the study for demonstrating extraluminal leakage. If the study is being performed in a spinal cord injury patient, it is critical to know the level of injury, as patients with injuries higher than T6 are at risk of autonomic dysreflexia. Once an adequate volume of contrast material has been instilled, the catheter is removed and a radiograph is obtained. The patient is then asked to void at which point frontal and oblique radiographs are obtained. Fluoroscopy is often used during VCUG and is an ideal way to evaluate the bladder neck and posterior urethra while a patient is voiding. Oblique radiographs are often necessary to identify low-grade reflux and posterior bladder diverticula. Post-void radiographs complete the examination. Alternatively, if the patient already has an indwelling urethral catheter and desired cystogram is all that is needed, the contrast can simply be drained through the catheter. The post-void or post-drainage image can be useful to identify urine leaks after surgery. [1] It is important to note that allowing excreted IV contrast to accumulate in the bladder is not a substitute for direct instillation of contrast into the bladder. For the evaluation of traumatic bladder injuries, plain film and CT cystography have similar sensitivity and **specificity**.[6]

2.3 Clinical Findings Which Can be Diagnosed on VCUG

See references 1,10

1. **Vesicoureteral reflux** (**Figure 7**)
2. Ureteral **ectopia** (if reflux is present)
3. Renal **duplication** (if reflux is present)
4. Bladder outlet obstruction
5. **Urethral stricture disease** (**Figure 8**)
6. **Fistulas of the urethra or bladder** (**Figure 9**)
7. Congenital **urethral anomalies**
8. **Diverticula of bladder and urethra** (**Figure 10A and 10B**)

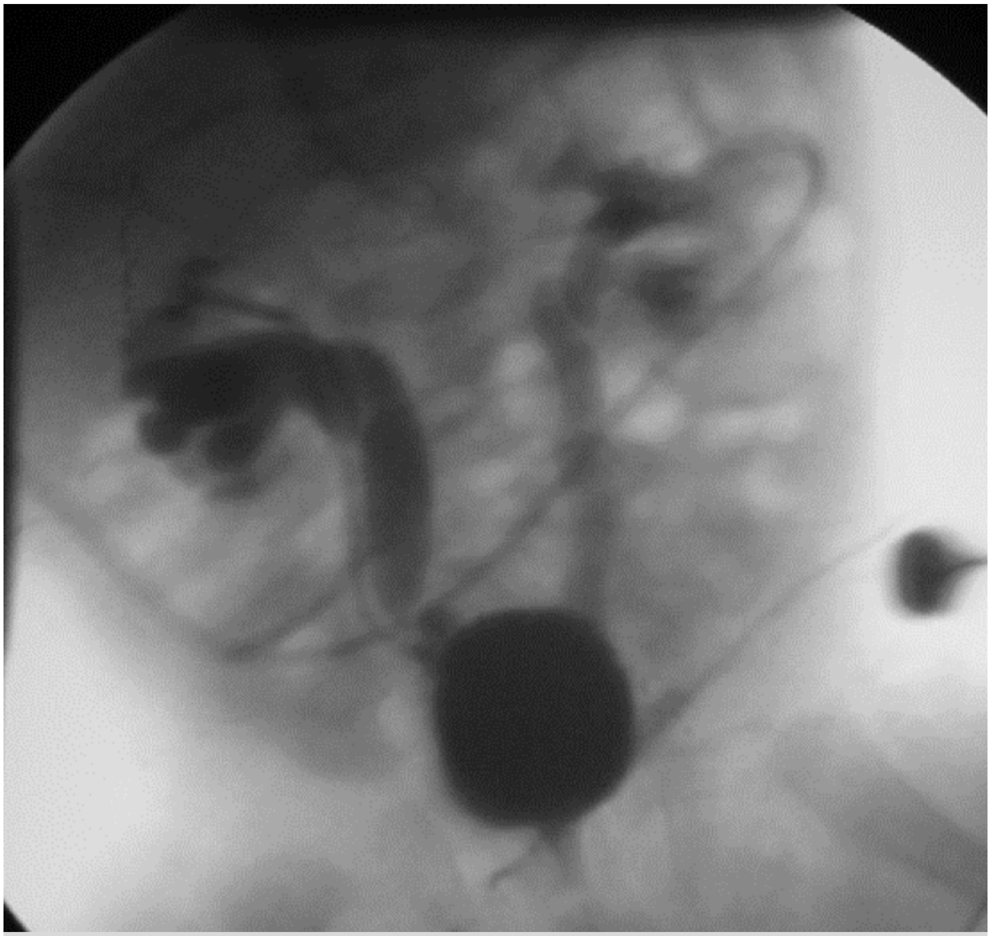

Figure 7 Voiding cystourethrogram demonstrating bilateral vesicoureteral reflux in a pediatric patient.

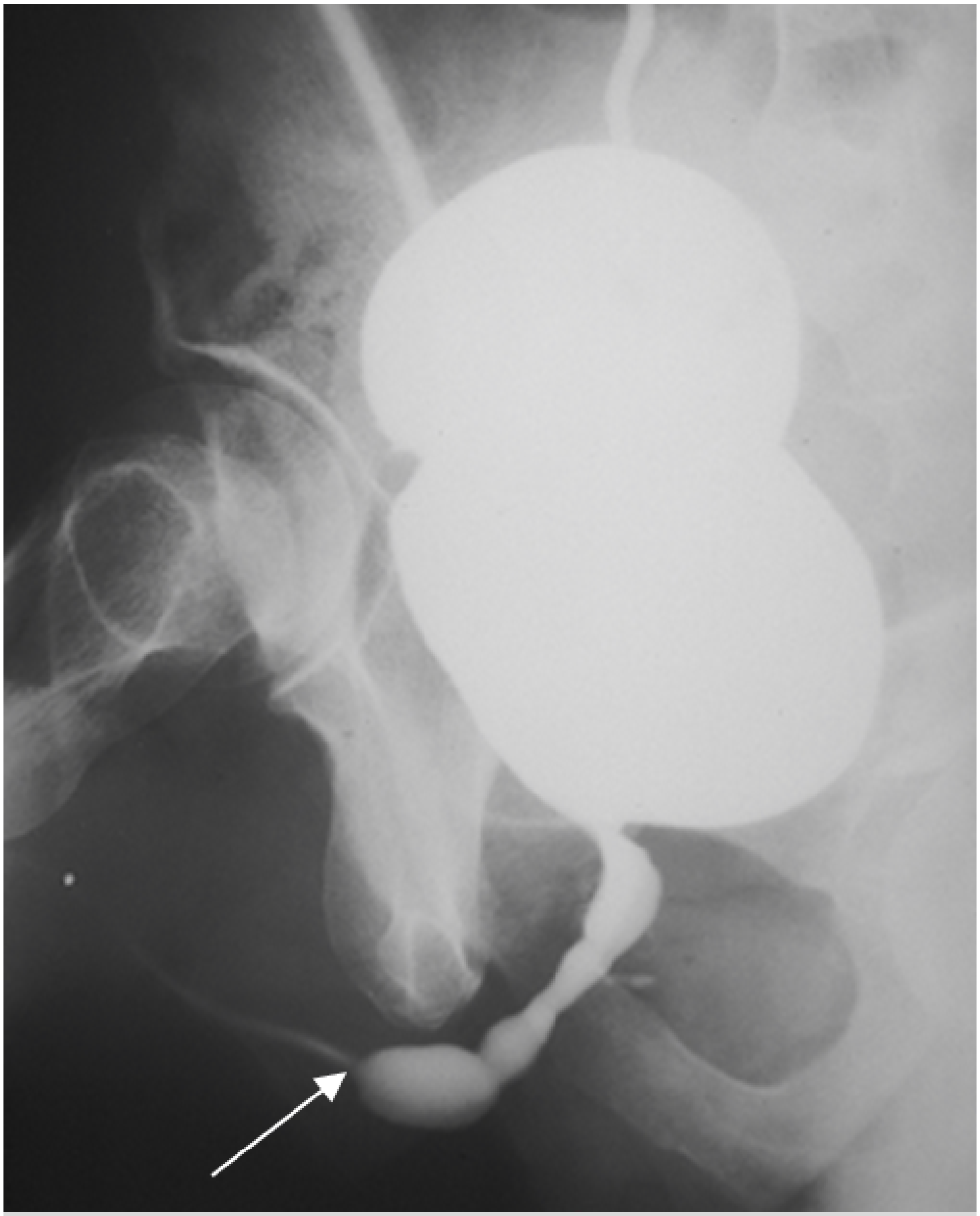

Figure 8 A voiding cystourethrography performed for evaluation of urethral stricture disease. The white arrow demonstrates a clear transition area in the penile urethra.

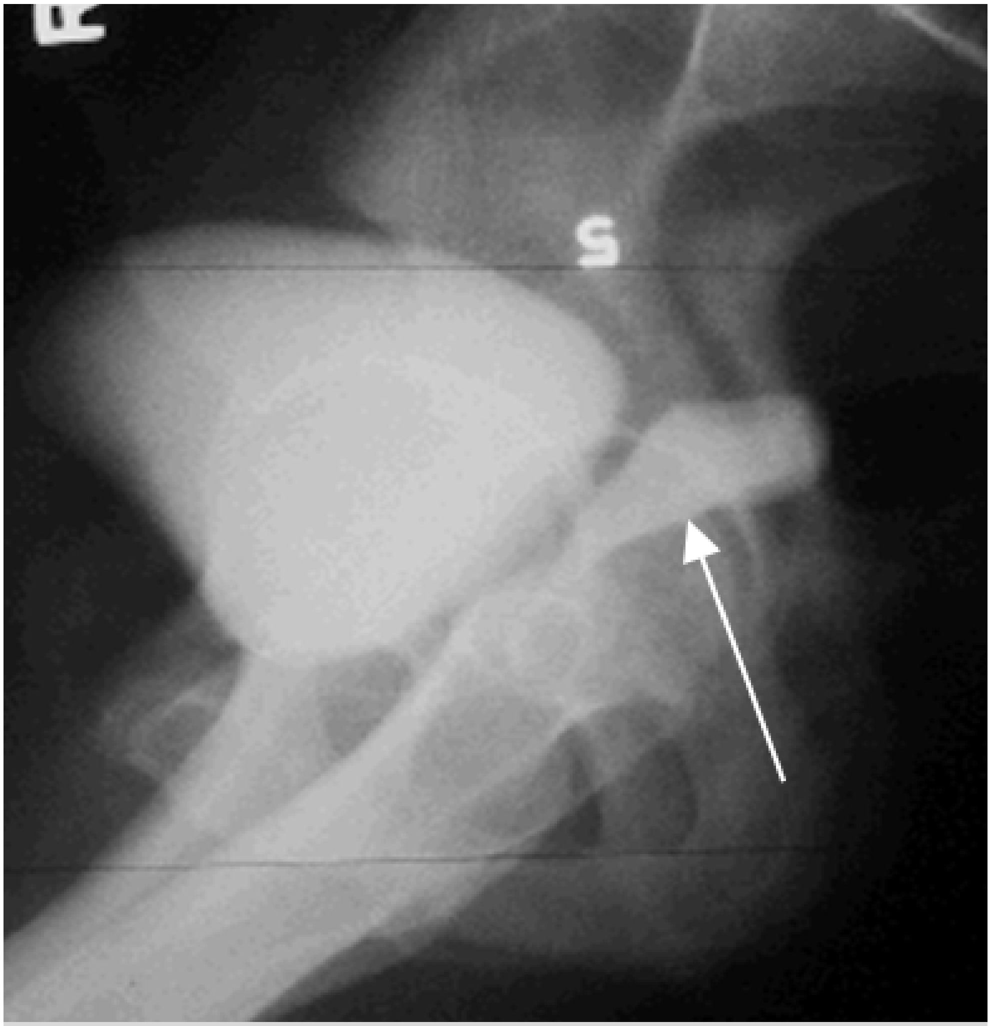

Figure 9 This voiding cystourethrogram clearly demonstrates contrast outside the bladder lumen (white arrow), suggestive of a fistula.

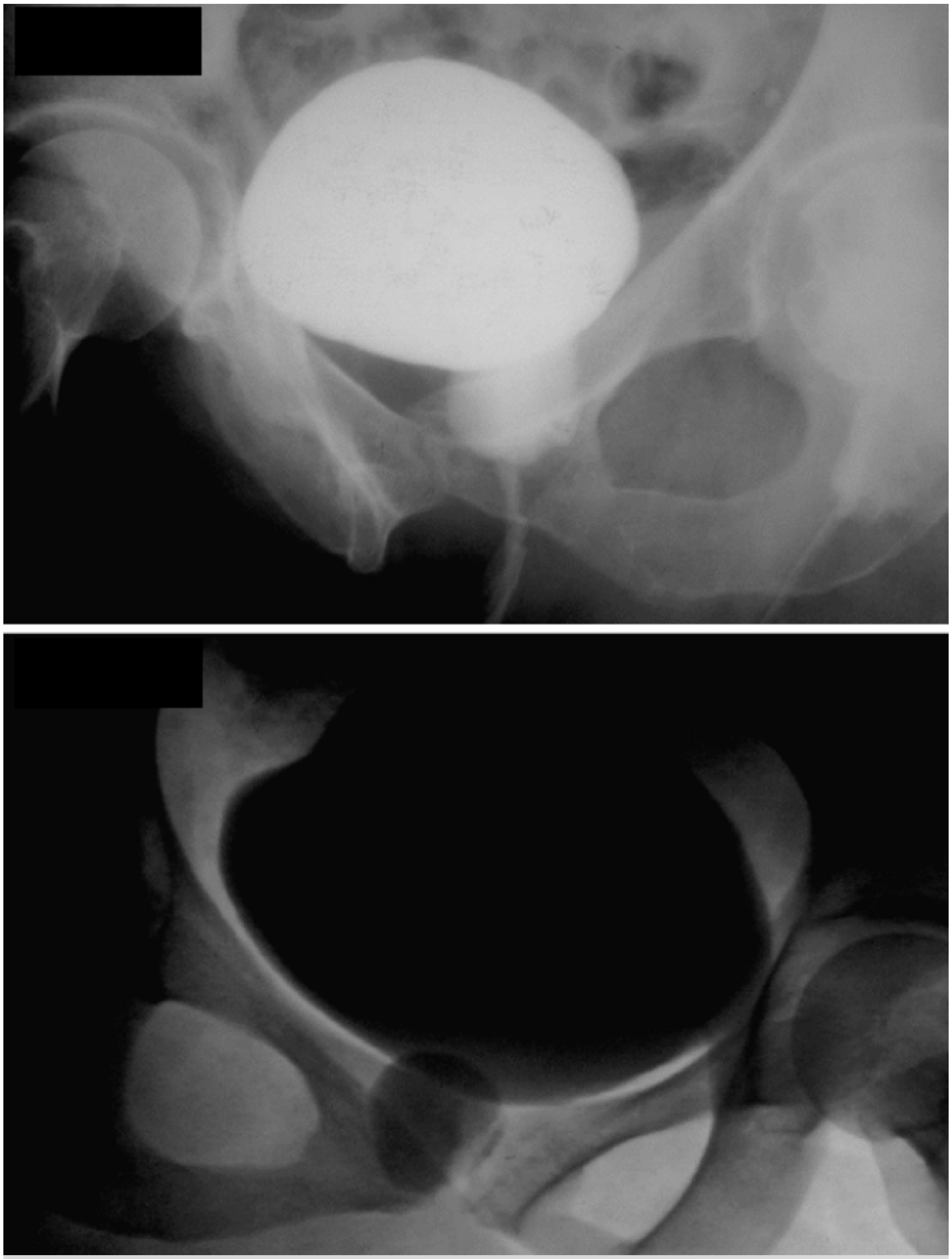

Figure 10 This voiding cystourethrogram demonstrates contrast in a urethral diverticulum (figures A and B).

3. Loopography

"Loopography" is analogous to voiding cystourethrography in patients with an ileal conduit (or loop) urinary diversion. This radiographic study can be performed in patients with any form of urinary diversion (continent or non-continent) for various indications. Often times, the term "pouchogram" is used when describing the same technique in a reservoir or neobladder. If the ureteroenteric anastomoses were performed in a refluxing manner, loopography is a valuable means of monitoring the upper tracts of bladder cancer patients; particularly in those with renal insufficiency in which intravenous contrast would be contraindicated. As the risk of systemic absorption is low, loopography can also be used in patients with caution in patients with iodinated contrast allergy. [3,11]

3.1 Indications for Loopography

1. Evaluation of the upper tract after urinary diversion (e.g., hematuria, obstruction, renal insufficiency)
2. Surveillance of upper urinary tract for urothelial carcinoma following radical cystectomy for bladder cancer (CTU is usually preferred for this indication)
3. Evaluation of intestinal segment used for urinary diversion (e.g., obstruction, leak, urinary tract infection, pain)

3.2 Technique

The technique is similar to that of VCUG. Peri-procedural antibiotics should be considered as most intestinal diversions are colonized with bacteria. A plain film radiograph is initially obtained prior to contrast instillation. For non-continent diversion, a 14-16 French Foley catheter is inserted into the loop. It is important to place the catheter past the level of the abdominal fascia with the balloon inflated and pulled back against the fascia to allow sufficient distension of the bowel segment. Contrast is then instilled through the catheter. Frontal and oblique radiographs are then obtained. Full views of the entire collecting system can be obtained in patients who adequately reflux. A post-drainage radiograph should then be obtained. The catheter can be removed prior to drainage of the loop to assess whether there is obstruction within the conduit.[1]

4. Retrograde Ureteropyelography (RPG)

Figure 11 Bilateral retrograde pyelogram demonstrating normal ureters and intrarenal collecting systems.

As the name implies, retrograde ureteropyelography (RPG) is a radiology study in which **contrast media is injected in a retrograde fashion to visualize the ureters and collecting system of the kidneys** (**Figure 11**). RPG offers several distinct advantages to IVU. First, there is no intravenous administration of iodinated contrast and therefore this procedure is safe in those with chronic renal insufficiency. Adverse reactions to contrast instilled during RPG are rare; however, in patients with a history of severe reactions to contrast agents, premedication with corticosteroids should be considered.[9] Furthermore, RPGs allow for excellent visualization of the ureter distal to an obstructing lesion which is often difficult to assess with IVP.[3]

4.1 Indications for RPG

1. Evaluation of **ureteral obstruction (congenital or acquired)**
2. Evaluation of filling defects and abnormalities of the ureters and collecting systems seen on other imaging techniques
3. Opacification of the collecting system to assist in percutaneous access for antegrade procedures
4. Opacification of the ureter and collecting system at the time of ureteroscopy or stent placement
5. Evaluation of hematuria in patients with chronic renal insufficiency or severe contrast allergy
6. Surveillance of **upper tract urothelial carcinoma** in patients with chronic renal insufficiency
7. Evaluation of **traumatic injuries of the ureter and collecting system**
8. Evaluation of a non-visualized portion of the ureter or collecting system from another imaging study (IVU or CTU)

4.2 Technique

RPG is performed via cystoscopic access, typically with the patient in the dorsal lithotomy position. Some form of anesthesia is preferable (monitored anesthesia care (MAC) or general) as distention and manipulation of the upper urinary tract can be quite painful for patients. Subsequently, a standard cystoscopic evaluation is carried out and the ureteral orifices are identified. In patients with active hematuria, bladder inflammation, or significant benign prostatic hyperplasia, identification of the ureteral orifices can sometimes be difficult.

A spot plain film radiograph of the abdomen and pelvis is taken prior to instrumentation. Once the ureteral orifices are visualized, a retrograde catheter is introduced through the working channel of the cystoscope. There are two basic types of catheters; non-obstructing and obstructing. Non-obstructing catheters (Pollack tip, spiral tip, whistle tip, or open-ended) can be gently passed up the ureter and into the collecting system, preferably over a guidewire to minimize trauma from the end of the catheter. The collecting system and ureter can then be visualized in its entirety by injecting contrast through the catheter while slowly withdrawing it. Alternatively, the ureter and collecting system can be opacified with the catheter tip at the most distal aspect of the ureter. Care must be taken to purge the catheter of any air prior to injecting as air bubbles can be mistaken for filling defects. Open ended catheters are useful for ureters which are difficult to access as they can be passed over a glide wire. Obstructing retrograde catheters (bulb tip, cone tip, or wedge tip) are inserted into the ureteral orifice to obstruct it at the time of contrast instillation.[1]

Care should be taken during injection not to over distend the collecting system, as this can result in pyelotubular, pyelolymphatic, and/or pyelovenous backflow. The **AUA Best Practice Statement on Antimicrobial Prophylaxis** recommends routine antibiotic prophylaxis for all procedures classified as cystourethroscopy with manipulation, including RPG.

5. Retrograde Urethrography (RUG)

Retrograde urethrography (RUG) is used to evaluate the anterior and posterior urethra in male patients (**Figure 12**). The posterior urethra can be difficult to evaluate in males with RUG due to increased resistance to contrast flow at the level of the external sphincter as well as the often coapting lateral lobes of the prostate. It plays a very minor role in the evaluation of the female urethra given its short length. [3]

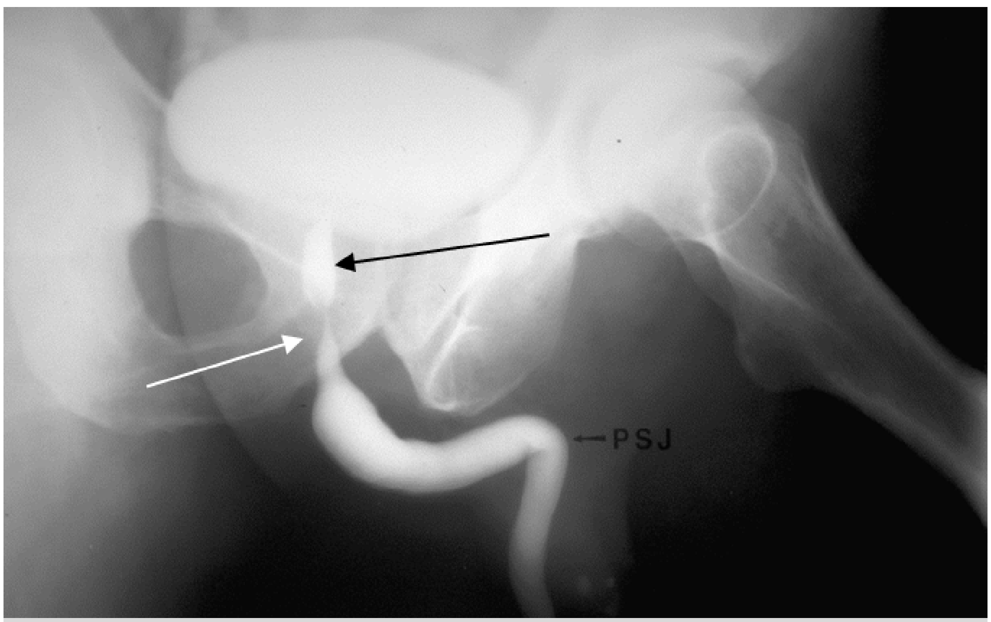

Figure 12 Normal retrograde urethrogram demonstrating the prostatic urethra (black arrow), the normal "cone" of the bulbar urethra (white arrow) with the membranous urethra proximal. PSJ: penoscrotal junction.

5.1 Indications for RUG

1. Detailed anatomic visualization of a urethral stricture: RUG is particularly useful in this setting to evaluate the urethra distal to the urethral stricture, but in order to quantify the length of severe strictures, may need to be combined with cystogram (assuming a suprapubic tube in place). (**Figure 13**)
2. Evaluation of suspected **urethral trauma** (**Figure 14**)

3. Evaluation of **urethral diverticula**, fistulous disease (**Figure 15**), and malignancy (**Figure 16**)
4. Evaluation of urethral foreign bodies
5. Evaluation of urethral healing after surgical repair.

5.2 Technique

A plain film radiograph should be obtained prior to contrast instillation. The patient can be placed in a modified oblique position with the weight-bearing leg flexed at the hip and knee. Alternatively, radiographs can be obtained in the frontal and oblique planes in order to assess the entire urethra. For contrast instillation, a small Foley catheter is inserted into the urethra to the level of the fossa navicularis and 2-3 mL of sterile water is placed in the balloon port to occlude the urethra. The penis can also be placed on stretch using a strip of gauze, which keeps the operator's hand out of the field. With the penis on mild stretch towards the flexed leg, contrast is then introduced via a syringe through the catheter. Gentle pressure can be applied with contrast instillation in order to fully distend the urethra.

RUG is commonly performed in the setting of suspected urethral trauma prior to attempted Foley catheter placement. Classically, blood present at the urethral meatus following a traumatic event should prompt a high suspicion for traumatic urethral injury.[1] Alternatively, if a foley catheter is already in place, a "peri-catheter" RUG can be performed by injecting contrast into the urethra along-side the catheter via an angiographic catheter.

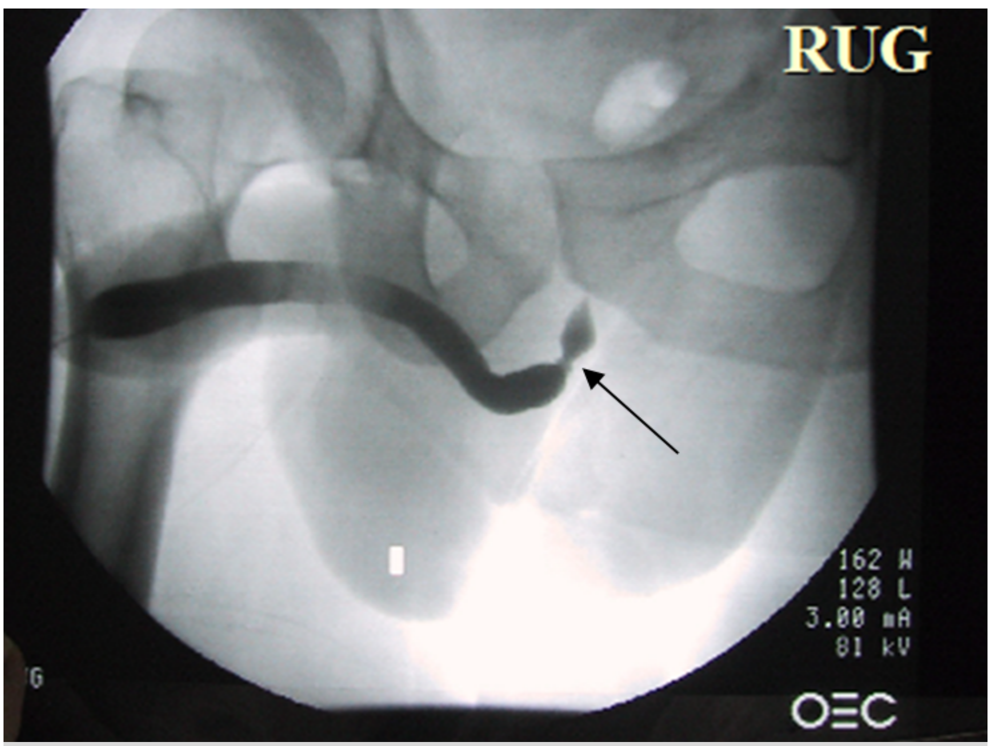

Figure 13 Retrograde urethrogram demonstrating the location of a urethral stricture (dark arrow) and the normal distal urethra.

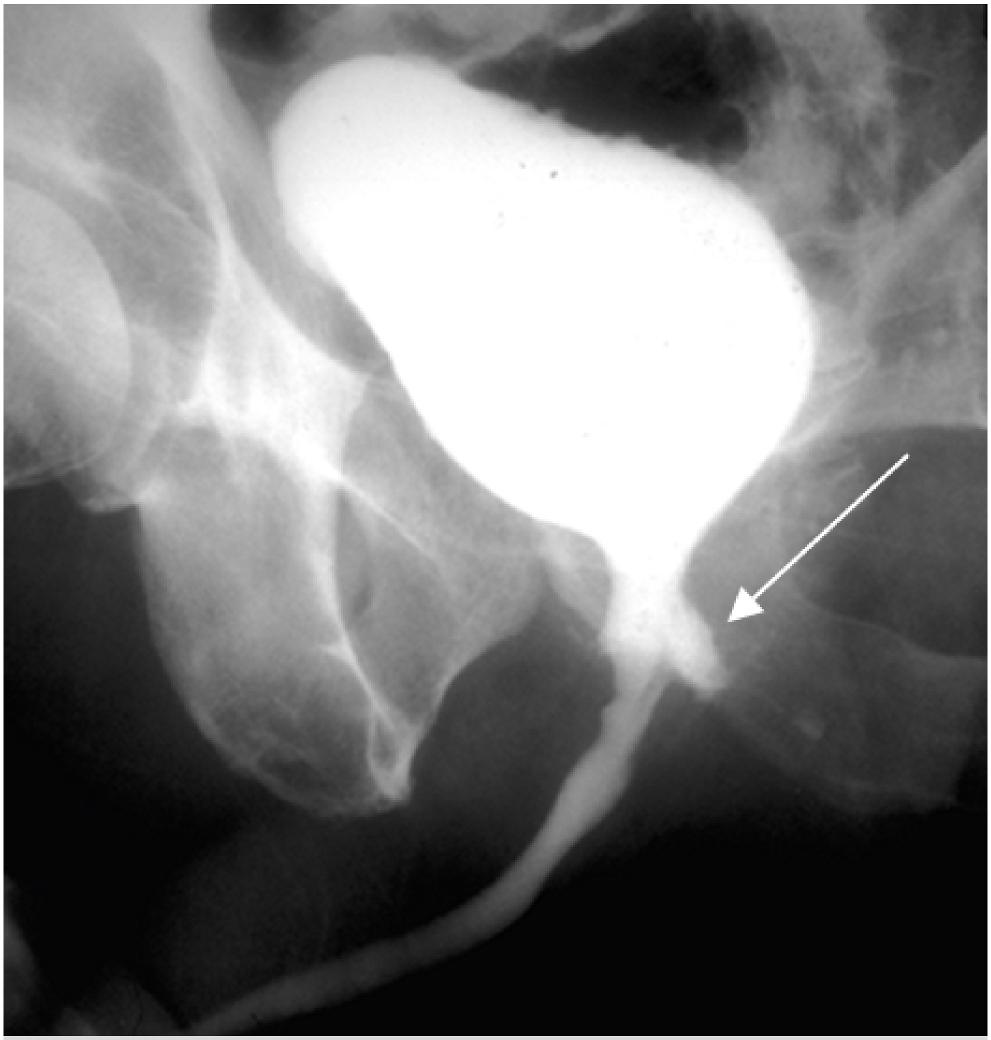

Figure 14 Retrograde urethrogram for evaluation of urethral trauma demonstrating a collection of extravasated contrast (white arrow).

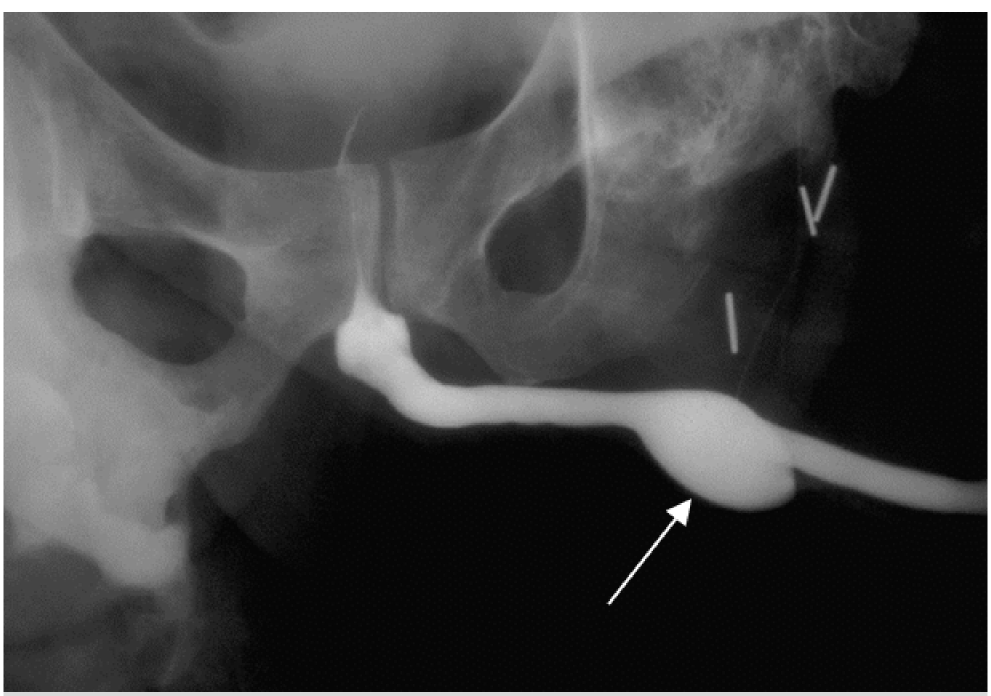

Figure 15 Retrograde urethrogram demonstrating a urethral diverticulum (white arrow).

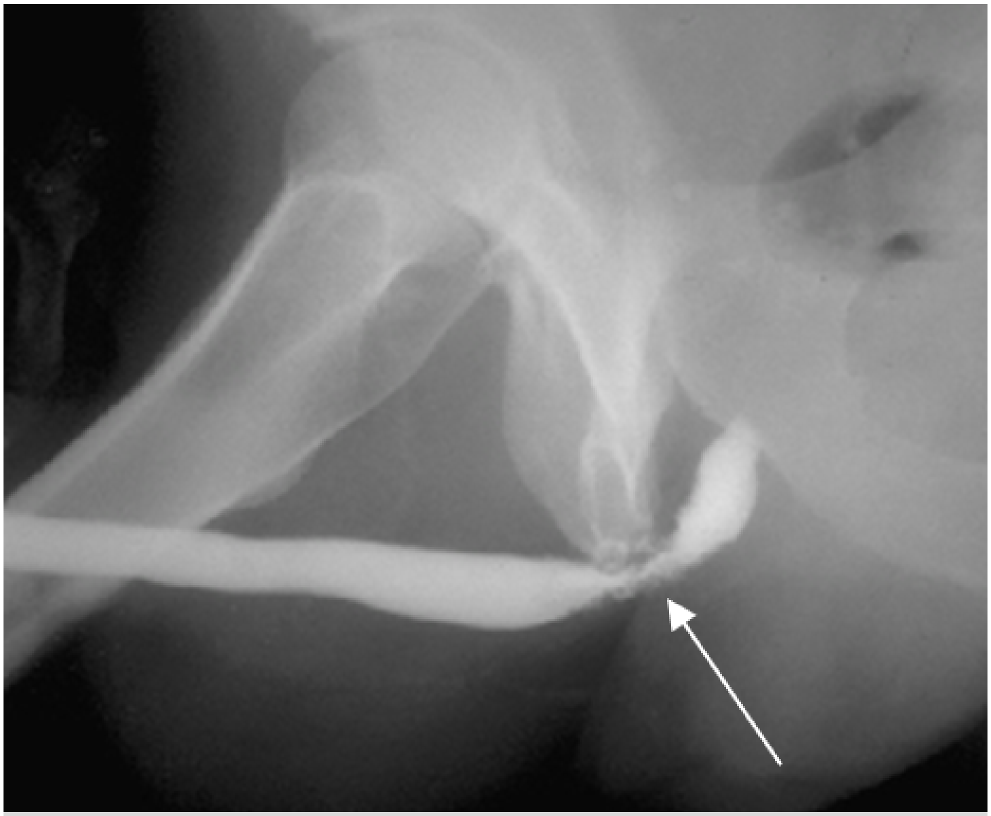

Figure 16 Retrograde urethrogram with findings of filling defects suggestive of a malignancy.

6. Conventional Angiography/Venography

Conventional angiography is a radiologic study that directly evaluates the arterial and venous systems using intravascular contrast material. While most urologists will not perform these studies, they may order them and co-manage patients with colleagues from vascular surgery and interventional radiology. Thus, a basic understanding is warranted. Arterial angiography that is specific to urologic diseases includes renal arteriography for evaluation of renal artery stenosis, adrenal arteriography, and pudendal arteriography for evaluation of vasculogenic erectile dysfunction.[1,3] Other angiographic applications are under investigation or entering clinical practice, including prostatic artery embolization for lower urinary tract symptoms[12] and bladder/prostate embolization for refractory gross hematuria.[13]

6.1 Renal Arteriography

Evaluation of renal artery stenosis: Renal angiography remains as the reference standard radiologic study for the evaluation of renal artery stenosis (**Figure 17**). However, several non-invasive techniques including Doppler ultrasound, computed tomography angiography (CTA) and magnetic resonance angiography (MRA) have supplanted conventional angiography as first-line studies for this indication.[14,15]

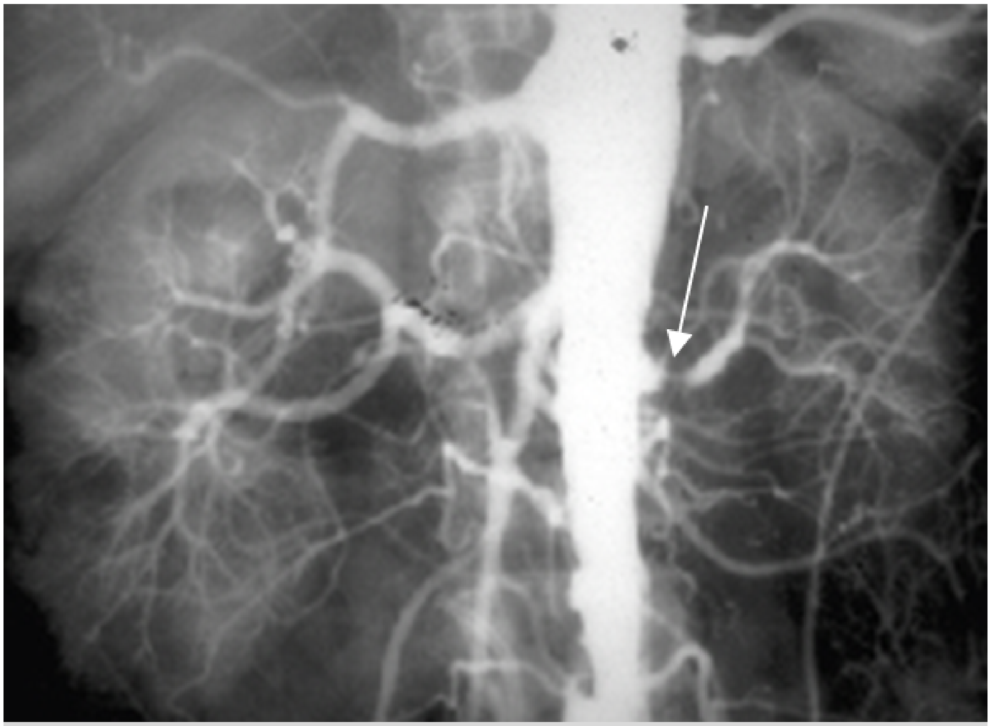

Figure 17 Renal angiography demonstrates left renal artery stenosis (white arrow).

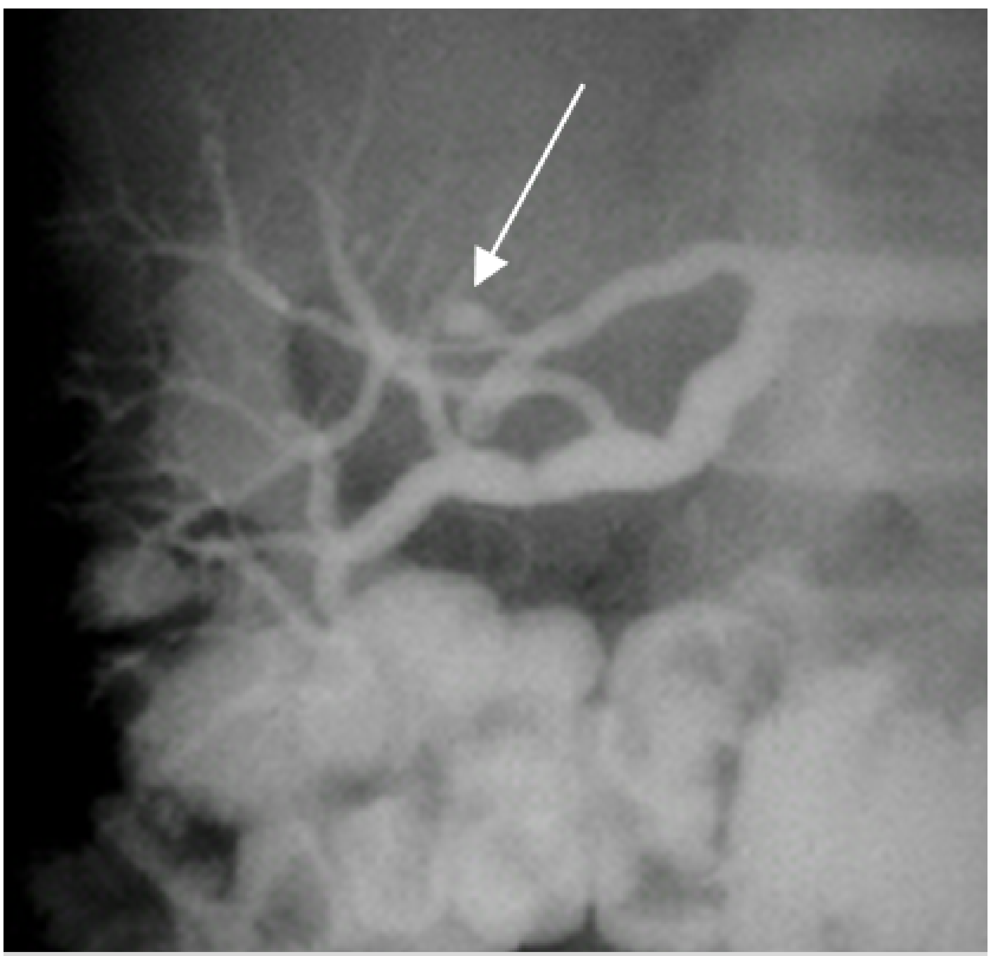

Figure 18 Demonstration of a renal artery pseudoaneurysm.

Renal trauma: The majority of renal parenchymal injuries can be adequately characterized with CT. Conventional renal angiography is typically reserved when intervention is required to stop renal bleeding refractory to conservative therapy. Angiography with embolization [16] can be performed in this setting by interventional radiologists. Similarly, conventional angiography with isolated vessel embolization can be performed for patients with post-operative hemorrhage following **partial nephrectomy** or **percutaneous nephrostolithotomy**.

Evaluation and treatment of vascular abnormalities: Renal artery pseudoaneurysms and arteriovenous malformations can be both evaluated and treated with conventional angiography (**Figure 18**).

Detailed anatomic vascular imaging: While conventional angiography has been employed in the past prior to renal surgical procedures, it has fallen out of favor due to the increased use of CTA and MRA.

6.2 Indications for Adrenal Gland Angiography

Adrenal gland embolization: There are several indications for adrenal artery embolization, which can be carried out at the time of conventional angiography. Embolization can be used in the oncological setting to palliate symptoms (pain) and reduce adrenal tumor bulk. It is also occasionally employed to reduce adrenal tumor vascularity preoperatively. Furthermore, it can be utilized for ablation of adrenal function in cases where there is excess adrenal hormone production.[1]

Adrenal vein sampling:[17] Functional adrenal lesions, such as in the setting of primary hyperaldosteronism, can be localized through venous sampling.

6.3 Indications for Venography

Venography can be used to evaluate renal vein and inferior vena cava thrombus level in patients with renal cell carcinoma with vascular involvement. This technique has largely been supplanted by CT and magnetic resonance imaging (MRI) which also provide detailed visualization of the venous anatomy prior to nephrectomy. [1]

6.4 Complications of Conventional Angiography

As with any invasive procedure, there are certain inherent risks associated with conventional angiography. Vascular complications associated with the vascular puncture tend to be minor including transient arterial spasm, hematomas, and pain. Such events rarely require intervention. Major complications associated with vascular puncture include hemorrhage, thrombosis, arterial dissection, and pseudoaneurysm formation. Intravascular injection of contrast can potentially cause acute tubular necrosis and associated renal insufficiency as well.[1,3]

7. Other Applications of Conventional Radiology

7.1 Vasography

Vasography is performed by directly instilling contrast into the vasa (**Figure 19**). It is rarely clinically indicated in the contemporary surgical management of **male infertility**; in fact, if not meticulously performed, it can lead to stricture or obstruction at the vasography site.[18] Vasography can identify the site of vasal obstruction (**Figure 20**) and should not be performed unless reconstruction is to be performed in the same setting.

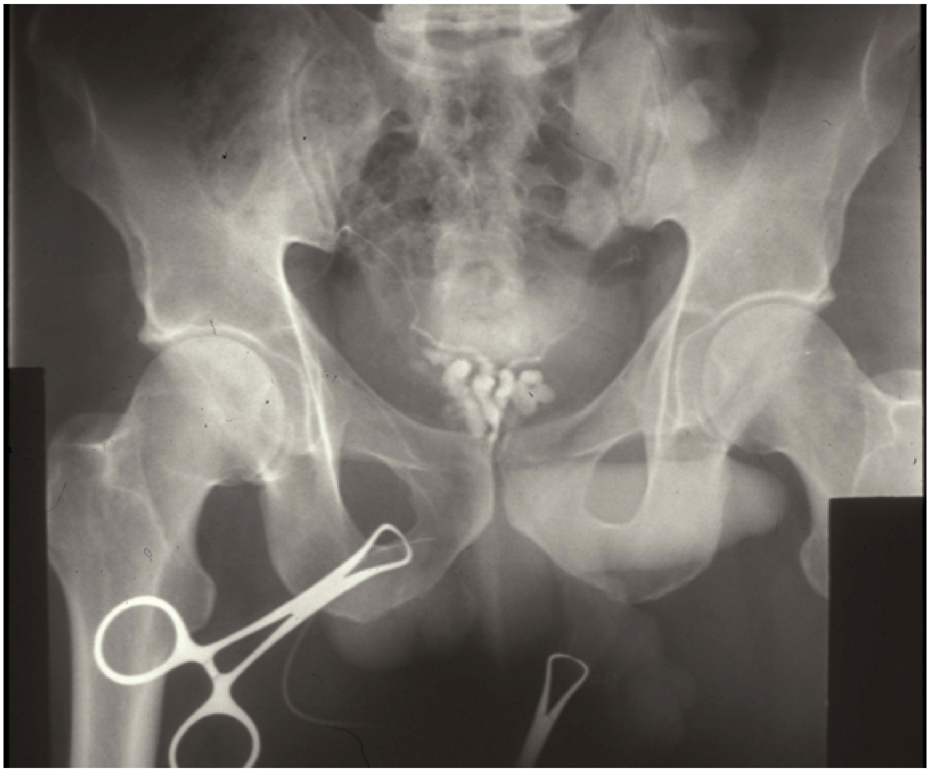

Figure 19 Normal vasogram, with retrograde filling of the bladder and seminal vesicals. Image provided by Dr. Peter Kolettis.

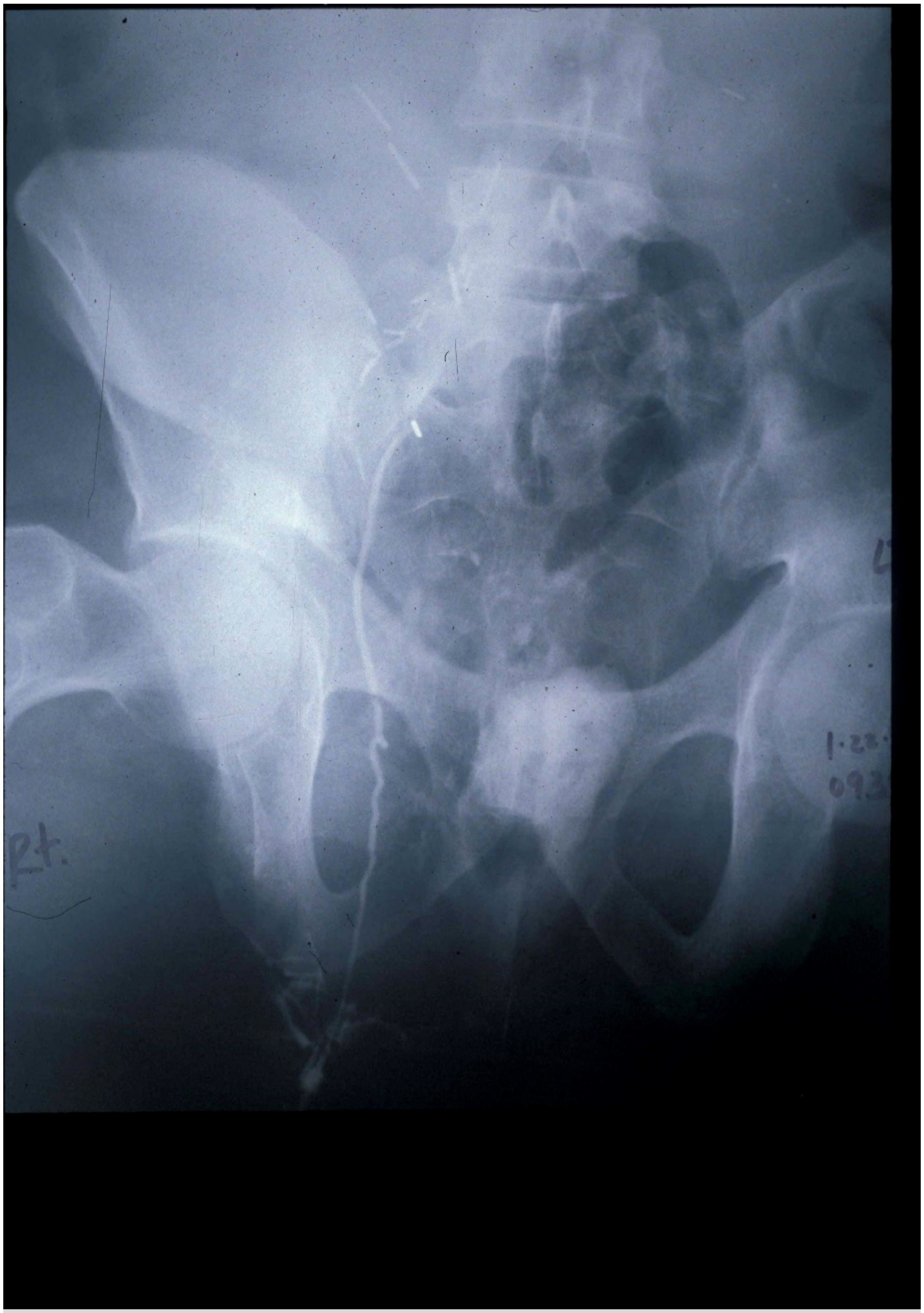

Figure 20 Right vasal obstruction at the level of a surgical clip from renal transplantation. Image provided by Dr. Peter Kolettis.

7.2 Lymphangiography

Lymphangiography is performed by interventional radiologists to opacify the lymphatic system. This is often done with diagnostic and therapeutic intent in the setting of lymphatic leak after pelvic or retroperitoneal surgery. Intralymphatic access can be obtained via the pedal or inguinal approach. Generally, an inguinal lymph node is identified via ultrasound, accessed via a 25g needle, and injected with lipiodol, an oil-based iodinated contrast agent with a tropism for the lymphatic system. If a leak is identified, embolization is carried out using a mixture of lipiodol and n-butyl-2-cyanoacrylate (n-BCA).[19]

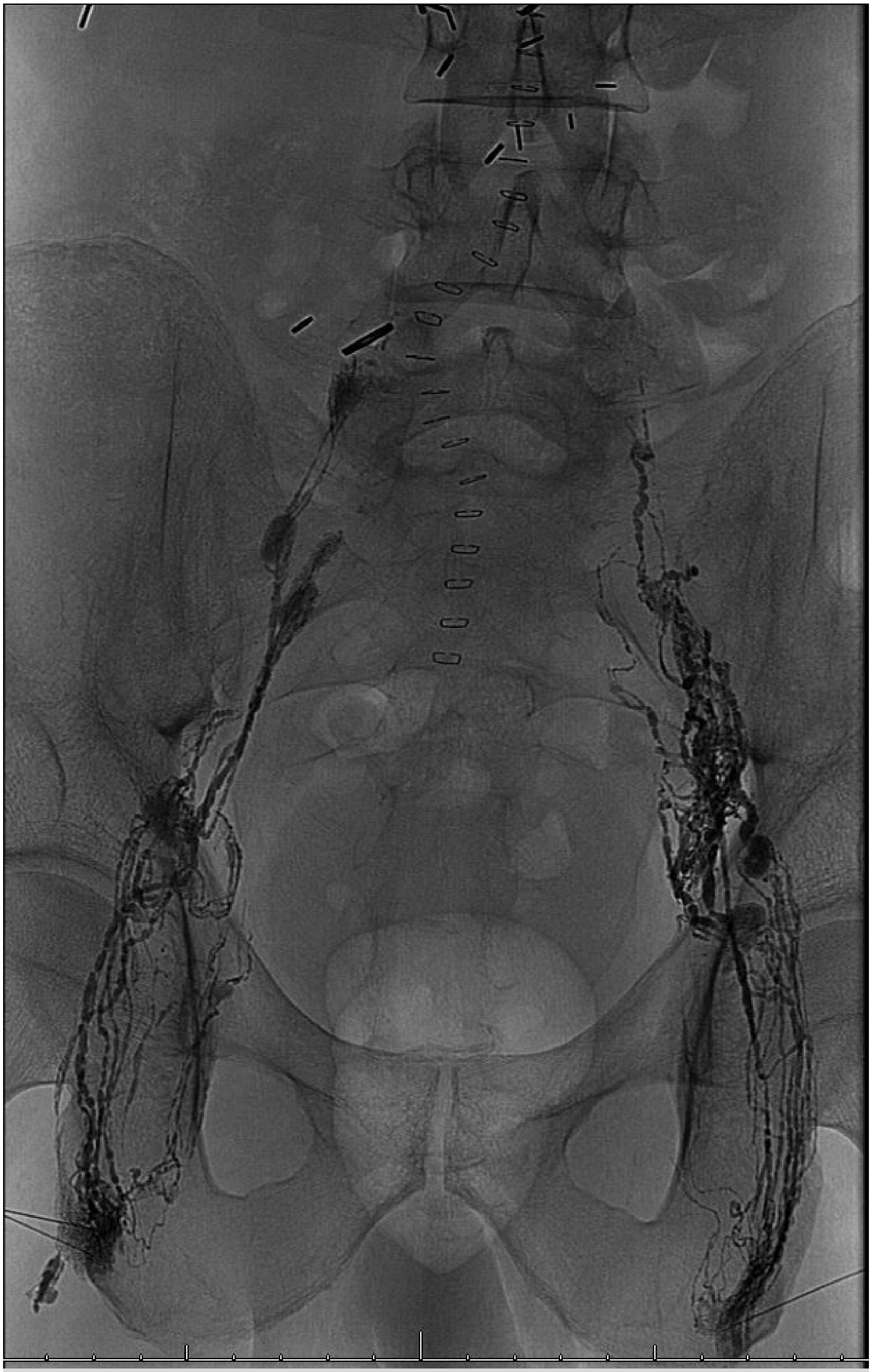

Figure 21 Bilateral inguinal intranodal puncture and pelvic lymphangiogram on patient with chylous ascites and right chylothorax after right thoracoscopic resection of lymphadenopathy, followed by retroperitoneal lymphadenectomy of post-chemotherapy masses for non-seminomatous germ cell tumor.

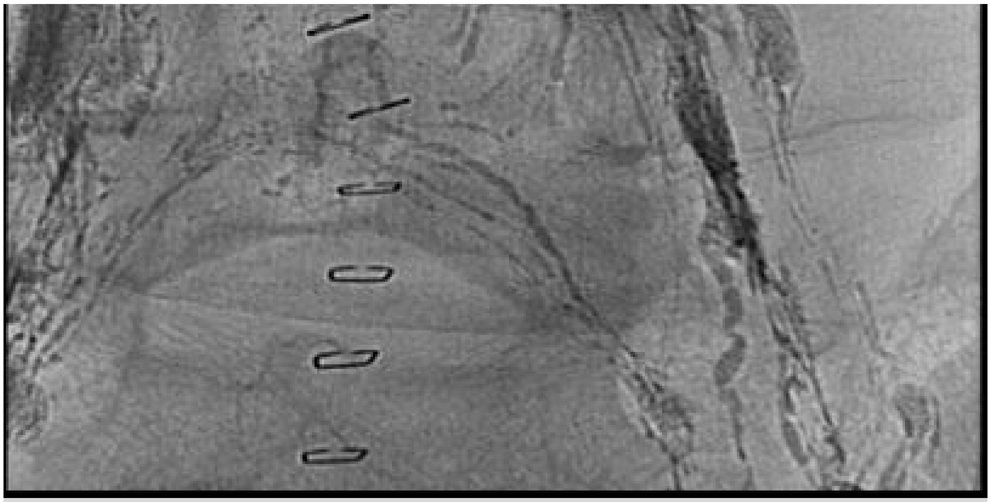
Figure 22. Delayed films from the same patient in Fig 21. Here, the cisterna chyli has been cannulated from an anterior percutaneous approach, and the right sided thoracic duct has been catheterized and embolized. The patient's refractory chylothorax and low volume chylous ascites immediately resolved.

Videos

Conventional Radiology Presentation 2022

Presentations

Conventional Radiology Presentation 1

References

1 Ramchandani P and Banner MP (2007): Clinical Manual of Urology: Fourth Edition. Chapter: 3.

2 Astroza GM, Neisius A, Wang AJ, Nguyen G, Toncheva G, Wang C et al (2013): Radiation exposure in follow-up of patients with urolithasis comparing digital tomosynthesis, non-contrast CT, standard KUB, and IVU. J Endourol Volume: 10; 1187-91

3 † Bishoff JT, Rastinehad AR (2021): Campbell-Walsh-Wein Urology: 12th Edition. Chapter: 4.

Comprehensive review of conventional radiology in urology.

4 Weese DL, Greenberg HM, Zimmern PE. Contrast media reactions during voiding cystourethrography or retrograde pyelography. Urology. 1993;41(1):81-4.

5 ☆ AUA Update Series Assessment and Management of Intraoperative Iatrogenic Ureteral and Bladder Injuries. Kreshover JE, Morganstern B and Richstone L, Vol. 32, Lesson 34, 2013

6 ☆ Morey, A. F., Broghammer, J. A., Hollowell, C. M., McKibben, M. J., & Souter, L. (2021). Urotrauma guideline 2020: AUA guideline. The Journal of urology, 205(1), 30-35.

7 ☆ Morey AF, Brandes S, Dugi DD 3rd et al: Urotrauma: AUA guideline. J Urol 2014, 192: 327. https://www.auanet.org/guidelines/guidelines/urotrauma-guideline

8 Dauw CA, Wolff JS Jr. Fundamentals of Upper Urinary Tract Drainage. In: Partin AW, Dmochowski RR, Kavoussi LR, Peters CA (ed.), Campbell-Walsh Urology. Philadelphia, Elsevier. 2021, pp. 160-184.e7.

9 Bishoff JT, Rastinehad AR. Urinary Tract Imaging: Basic Principles of CT, MRI, and Plain Film Imaging. In: Partin AW, Dmochowski RR, Kavoussi LR, Peters CA (ed.), Campbell-Walsh Urology. Philadelphia, Elsevier. 2021, pp. 28-67.e5.

10 Riccabona M (2006): Imaging of the neonatal genito-urinary tract. Eur J Radiol. Volume 60; 187-198.

11 Hudson HC, Kramer SA, Anderson EE: Identification of ureteroileal obstruction in retrograde loopogram, Urology 17:147–148, 1981.

12 Carnevale FC, Moreira AM, Moreira de Assis A, et al. Prostatic Artery Embolization for the Treatment of Lower Urinary Tract Symptoms Due to Benign Prostatic Hyperplasia: 10 Years' Experience. Radiology 2020; 296:444–451

13 Loffroy R, Pottecher P, Cherblanc V, et al. Current role of transcatheter arterial embolization for bladder and prostate hemorrhage. Diagn Interv Imaging 2014; 95(11): 1027-1034.

14 Sarkodieh JE, Walden SH and Low D (2013): Imaging and management of atherosclerotic renal artery stenosis. Clin Radiol Volume: 68; 627-635.

15 Tafur-Soto JD1, White CJ2. Renal artery stenosis. Cardiol Clin. 2015 Feb;33(1):59-73. PMID: 25439331.

16 ☆ AUA Update Series The Use of Percutaneous Transcatheter Embolization in 424 Urology. Ward JE, Amling CL and McKusick MA, Vol.XXII, Lesson 39, 2003

17 ☆ AUA Update Series Assessment and Management of an Adrenal Mass in Urological Practice. Kutikov A, Mehrazin R and UzzoRG, Vol. 33, Lesson 19, 2014

18 Goldstein M. Surgical Management of Male Infertility. In: Partin AW, Dmochowski RR, Kavoussi LR, Peters CA (ed.), Campbell-Walsh Urology. Philadelphia, Elsevier. 2021, pp. 1453-1484.e4.

19 Moussa AM, Camacho JC, Maybody M, Gonzalez-Aguirre AJ, Ridouani F, Kim D, Laudone VP, Santos E. Percutaneous Lymphatic Embolization as Primary Management of Pelvic and Retroperitoneal Iatrogenic Lymphoceles. J Vasc Interv Radiol. 2021 Aug 4:S1051-0443(21)01273-2. doi: 10.1016/j.jvir.2021.07.022. Epub ahead of print. PMID: 34363941.