9 Interventional Radiology as a Therapeutic Option for Complicated Appendicitis

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Case Example

A 9-year-old previously healthy boy presented with right lower quadrant pain, WBC of 22 and an ultrasound (US) showing a 5.3 × 2 .2 cm thick-walled, complex fluid collection was identified in the pelvis (Fig. 9.1a). Magnetic resonance imaging (MRI) was performed, confirming a rim-enhancing fluid collection containing gas. A 12 French percutaneous drain was placed transrectally (Fig. 9.1b) with ultrasound guidance by interventional radiology (IR) on hospital day 1, with aspiration of 35 ml of purulent fluid.

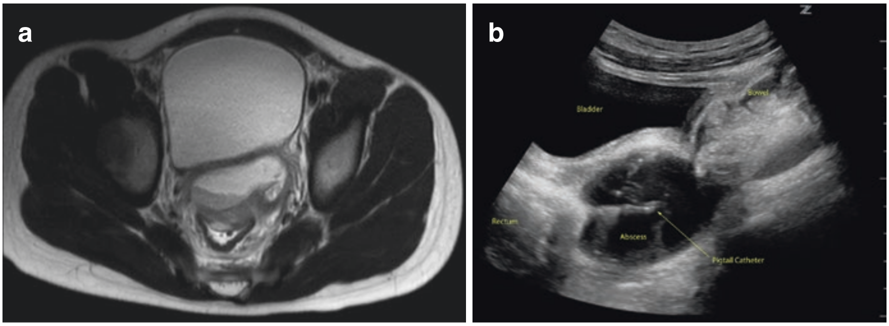

Fig. 9.1 (**a**) Axial T2W image of the pelvis showing an abscess anterior to the rectum. (**b**) Sagittal ultrasound image through the bladder showing transrectal drain in pelvic abscess

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Introduction

Acute appendicitis is one of the most common surgical pathologies in the United States, with perforation not uncommon in children and a reported 10–13% rate of associated abdominal abscess [1, 2]. Historically, the gold standard in treatment of abdominal abscesses has been with surgical drainage and debridement. Percutaneous drainage of an abdominal abscess was first reported in 1842 by a surgeon named Murray, who described the placement of a trocar and cannula into a liver collection “until adhesions formed between the liver and abdominal wall” [3]. Over the past several decades, however, percutaneous drainage (PD) has become the preferred method of treatment in adults and children alike as it is associated with a lower morbidity and mortality as compared to open surgical drainage [4–8]. PD is now recommended as first-line therapy for abscesses related to acute appendicitis by the World Society of Emergency Surgery and the Surgical Infection Society [9, 10].

Pre-procedure Evaluation

Abscess Identification

Acute appendicitis is a clinical diagnosis, though imaging has become a mainstay for complete evaluation. Classically, patients present with fever and abdominal pain, which over time localizes to the right lower quadrant. An abscess related to perforation may be identified on imaging, affecting patient management. Especially in small children, ultrasound is the preferred imaging modality as it avoids radiation exposure. Pediatric small body habitus lends itself well to identification of an enlarged appendix or a fluid collection by ultrasound. Diagnostic imaging findings of abscess are explained in more detail in an earlier chapter, but in general consist of thick-walled, often complex fluid collections. The appendix may also be identified in the region of the collection, with or without the offending appendicolith. If evaluation by ultrasound is limited and clinical suspicion remains high, MRI or CT may be considered. More recently, magnetic resonance imaging (MRI) is the preferred second-line imaging modality, as it avoids radiation exposure [11]. Abbreviated MRI protocols have been created to limit time on the scanner both to avoid sedation and conserve MRI time. For younger children, sedation still may be required for the use of MRI, the risk of which may be considered greater than the potential benefit. For this reason, CT is often the best second-line modality. A CT can be obtained in a manner of seconds, requiring no sedation or scheduling difficulties. Potential downsides of CT imaging include radiation exposure and protocols that may require oral contrast to better delineate bowel and appendix lumen. Transit of oral contrast may take up to 2–3 hours to reach the cecum.

Laboratory Studies

The most important preoperative laboratory studies are coagulation parameters, although evaluation may be deferred if the patient has no medical history of coagulation abnormality [12]. A platelet count greater than 50,000/uL is recommended by the Society of Interventional Radiology (SIR). An international normalized ratio (INR) less than 1.2, or less than 1.5 for urgent cases, is recommended [13]. A cutoff of 1.7 is used in many IR divisions. Occasionally, percutaneous drainage requires traversal of an organ, such as liver, stomach, or even bladder, which may be safely done, but more strongly requires evaluation of coagulation parameters due to the increased bleeding risk. Laboratory values outside of these recommendations require correction by pretreatment with oral vitamin K or fresh frozen plasma (FFP) for abnormal INR, cryoprecipitate, or platelet infusion. In many IR divisions, intra-procedural administration of FFP for an INR 1.7–2.0 and platelet transfusion for platelet counts of 25,000–50,000/uL are acceptable alternatives, which allow for timely patient care.

Antibiotic Therapy

Intravenous antibiotics are initiated at the time of patient diagnosis. If there is high concern for septicemia at the time of drain placement, coordinating the timing of the antibiotic to the 1 hour immediately prior to the procedure, or administering an additional dose, may be considered. Concern for septicemia is highest when the collection is present within a vascular organ, such as the liver [14].

Imaging Guidance for Drain Placement

Once an abscess is identified, the preferred method of management is by percutaneous drainage, which has lower morbidity and mortality risks than open drainage. US is largely the imaging modality of choice given its ability to provide real-time guidance and its radiation-free character. In adults or children with large body habitus, US visualization of the collection or adjacent structures may be limited. CT guidance provides for safe trajectory planning and procedural success. Small patient size makes US utilization more successful in children than in adults. When collections are present in the deep pelvis or encompassed by loops of bowel, however, US may not be safely performed, and CT is the preferred modality. Real-time MRI guidance is available at the author's institution and is used for core biopsies, but MRI-compatible guidewires and MRI-compatible drains are just now becoming available in the United States, and so MRI is not widely used at this time. Cone-beam CT with guidance abilities in IR suites which have the capable equipment and software. Cone-beam CT does produce radiation, however, and the image quality is somewhat less than a typical CT scan. The benefit of cone-beam CT is that it can provide real-time guidance.

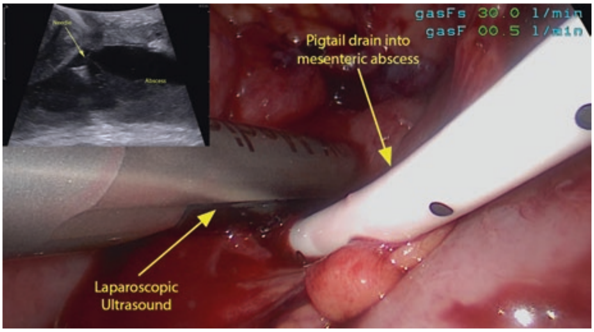

Fig. 9.2 Laparoscopic ultrasound-assisted drainage of deep abscess in abdomen

The real-time ability of US guidance has several advantages. The access needle and wire are visualized within the collection as they are placed. This allows for short procedure times, minimizing sedation requirements. The real-time guidance also provides a potential for greater control and accuracy of the path of the needle. CT-guided drain placement can take longer, as it is performed by instrument adjustment and stepping out of the procedure room for CT imaging. CT fluoroscopy may be utilized, if available, which can shorten the procedure. During CT fluoroscopy, 1–3 slice images are obtained by the use of a foot pedal. The interventionalist remains in the room or even with a hand on the instrument for guidance. Imaging is not truly real-time, but radiation dose is reduced by imaging smaller portions of the patient.

For deep pelvic collections, in close approximation to the rectum, transrectal drain placement may be considered. This allows for radiation avoidance by using a transrectal or transabdominal ultrasound probe for drain placement, detailed below.

For collections that are located more superiorly in the abdomen but covered by mesentery, or for those that are deep to multiple loops of bowel, laparoscopic-assisted ultrasound drainage of the abscess is effective. This allows easy manipulation of the bowel from the path of the drain (Fig. 9.2).

Indications for Percutaneous Drainage

Percutaneous drainage (PD) of peri-appendiceal abscess with interval appendectomy has been shown to have fewer complications than immediate appendectomy with a similar rate of clinical improvement [15–19]. Imaging findings to suggest infection include a thick wall around the collection, adjacent inflammation, wall enhancement, and the presence of air bubbles. Abscesses less than 3 cm are generally treated with antibiotic therapy alone, with a reported success rate of 88% based on an early study [20]. Aspiration can be performed if culture is desired for antibiotic tailoring. If a fistula is visualized during aspiration, a drain should be placed [21].

Contraindications to Percutaneous Drainage

PD of peri-appendiceal abscesses have been associated with a 4.5–26% failure rate in adults [7, 8]. A major contraindication to PD is inability to safely access the collection without injury to an adjacent organ, most importantly, a vascular structure

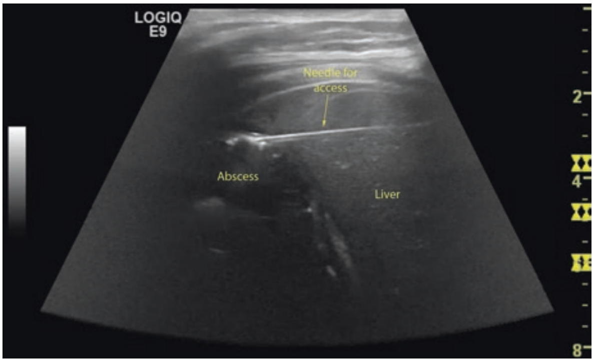

Fig. 9.3 Ultrasound-guided transhepatic placement of needle into a subphrenic abscess from perforated appendicitis for drain placement

or bowel. Safe and effective transhepatic abscess drainage of upper abdominal collections has been described (Fig. 9.3), as has transvesicular drainage of pelvic fluid collections [16, 17]. Trans-pleural access should be avoided, to prevent spread of infection into the sterile pleural space. Bleeding diathesis or other coagulation abnormalities represent another important contraindication, though often risk of bleeding can be mitigated by transfusion of platelets or fresh frozen plasma to facilitate the less invasive PD placement and avoid open surgical intervention.

Procedural Considerations

The decision to place an abdominal drain is based on multidisciplinary discussion and consideration of patient-specific factors. After a discussion of the benefits, risks, and alternatives, informed consent is obtained from the patient's parent or legal guardian prior to the procedure. Sedation or general anesthesia is required for most pediatric drain placements, if not only to prevent patient discomfort but also to maximize the safety and success of the procedure by preventing patient movement. Liberal administration of local anesthetic is used to assist with pain management, paying particular attention to the peritoneal lining, which can be the most painful point of transgression. Attention should be paid to weight based maximum dosages to prevent systemic toxicity.

The choice of US or CT guidance is based on the location of the collection, the size of the patient, and the comfort level of the performing physician. When possible, ultrasound guidance is preferred, in accordance with ALARA principles (as low as reasonably achievable) [22, 23]. As discussed above, US is the preferred modality for procedural guidance, given the lack of ionizing radiation exposure and real-time guidance (Fig. 9.4). A potential downside in the use of US is that it cannot penetrate artifact related to bowel gas or gas within the collection itself. Careful comparison with prior imaging may provide reassurance that a gas-filled region on US represents the target collection, but typically then requires the use of another imaging modality to confirm catheter placement. This can be achieved either by CT to delineate the location of a guidewire, fluoroscopic imaging with contrast injection through the access needle, or cone-beam CT to prevent placement of a drain into bowel.

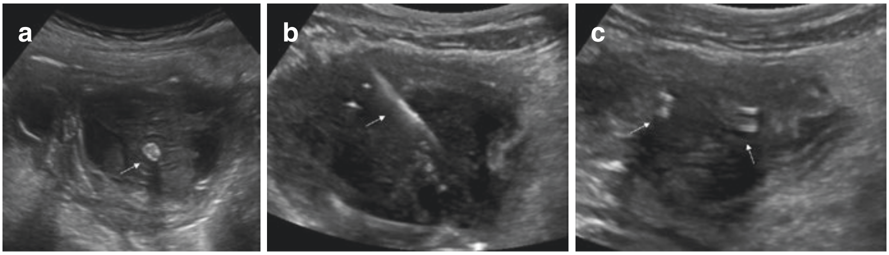

Fig. 9.4 (**a**) Sagittal grayscale Doppler ultrasonography demonstrates a complex fluid collection with internal echoes and a thick wall, consistent with abscess. An echogenic and shadowing focus in its central aspect represents an appendicolith (white arrow). (**b**) and (**c**) Transverse grayscale Doppler ultrasonography showing wire placement within the collection during drain placement (white arrow) and double echogenic lines of the catheter loop within the collection, with overall decrease in volume after aspiration

Basic Drainage Technique

There are two techniques utilized for drain placement: trocar technique and the more commonly used Seldinger technique. The trocar technique can be used when a collection is superficial or crosses a plane at high risk of loss of access during serial dilation. The Seldinger technique utilizes a smaller access needle and allows for confirmation of needle location within the collection prior to dilation and drain placement.

Regardless of the imaging modality utilized for guidance, preliminary imaging is performed to assess the safest route for drainage, avoiding vascular structures and abdominal organs. A radiopaque marking grid is placed in the expected region of safe access route based on prior imaging for CT-guided procedures. Patient comfort is also taken into account, placing the tube insertion site in a location that will not result in pressure on the tube while sitting or recumbent and avoiding a location which might be exposed to pressure related to clothing, if possible. When unavoidable, transgluteal route may be necessary, but can be associated with significant patient discomfort. For this reason, transrectal or transvaginal catheter placement is preferred for deep pelvic collections, located anterior to the rectum. Although placement can be slightly more challenging and there is a risk of catheter dislodgement, patient comfort is greater in these locations, and outcomes are similar.

Once a suitable access route is identified, sterile preparation of the access point is performed. For ultrasound-guided procedures, local anesthesia is then administered, and the access needle is advanced into the collection under direct visualization. Using the trocar method, the catheter itself with needle stylet is advanced through a small incision into the collection in one step. The catheter is advanced over the needle stylet, curling the distal "pigtail" loop within the collection. Aspiration then should yield fluid, and once confirmed within the collection, the loop is locked, catheter is secured to the skin by suture, and a dressing is placed.

Using Seldinger technique, either an 18-gauge needle or a 5French/19-gauge centesis catheter with introducer needle is advanced into the collection under ultrasound guidance. Aspiration yields fluid, confirming position within the collection, and the catheter is advanced over the needle into the collection further. The needle is exchanged for a guidewire, over which the centesis catheter is exchanged for the drainage catheter after serial tract dilation, if necessary. The trocar method may be preferred for transrectal or transvaginal drainage, as serial dilation of the tract may dislodge the guiding wire from the collection during exchanges.

When using ultrasound for transrectal or transvaginal guidance, a curved (for larger children) or linear (for small children) probe may be used for visualization of the pelvic collection from the anterior abdomen, taking advantage of the phenomenon of acoustic enhancement through the bladder for visualization of the collection and needle (Fig. 9.1a). Acoustic enhancement consists of the characteristic of simple fluid (urine, in this case) to appear to delineate deeper structures with more clarity and echogenicity (brightness), as soundwaves are attenuated less by the fluid than by adjacent soft tissue structures. Using the trocar technique, the drain with blunt stylet is then advanced through the rectum with a finger near its tip toward the collection. The blunt stylet is then exchanged for the needle stylet and advanced through rectal/vaginal wall into the collection under direct visualization. Alternatively, an 18-gauge needle can be advanced through the rectum in a similar manner, using a plastic tubing which has been split longitudinally for a modified peel-away sheath to protect the rectal/vaginal wall from injury during needle advancement. If the patient is too large, however, the transabdominal technique will not be successful. A rectal/vaginal ultrasound probe is then used, with or without the needle guide attachment, to place the needle into the collection alongside to the probe. The catheter is then secured to the inner thigh using an adhesive catheter securement device.

A similar technique is employed for CT guidance. A radiopaque grid is used to mark the optimal insertion site, and a trajectory is mapped out on imaging. The depth of the collection from the skin surface is measured, and after sterile preparation, local anesthetic is administered, and the anesthetic needle is advanced through the skin at the determined angle to access the site. Repeat imaging is performed, either using a foot pedal for CT fluoroscopy or with 5–7 axial slices centered on the needle insertion site. Once a satisfactory trajectory is confirmed using the small anesthetic needle, an incision is made, and an 18-gauge needle or 5French/19-gauge centesis catheter. The introducer needle is then advanced to determine the depth at the appropriate angle. Aspiration can then be performed, and if fluid is aspirated, a guidewire is advanced through the needle or centesis catheter after removal of its introducer needle. Repeat imaging may be performed to confirm wire location within the collection, or serial tract dilation with catheter placement is performed without repeat imaging if there is confidence in wire location. Once the catheter is advanced into the collection, aspiration should yield additional fluid, the loop is locked, and final CT imaging is performed to document/assess catheter position. The catheter is then secured to the skin with suture and a dressing applied.

Regardless of technique, the catheter is attached to closed suction drainage bulb (e.g., a Jackson-Pratt) or a drainage bag for gravity drainage. JP bulb use may be preferred, given the likely superior drainage of thick pus by suction.

Post-procedure Management

Patients should be assessed daily for persistent/recurrent fever or worsening abdominal pain. Drain output should be recorded for every 8–12 hour shift by nursing staff. 5–10 ml saline flushes every 8–12–24 hours is recommended to prevent catheter occlusion by debris [1, 24, 25]. The volume of the flush is subtracted from the total output volume at the time of output documentation.

Catheter removal is considered when the patient has remained afebrile, is clinically improving, and catheter output is less than 5–10 ml over 24 hours [26–28]. No follow-up imaging is required if the patient has clinically improved and total output is as expected for the size and complexity of the collection. Repeat imaging is performed if drain output is lower than expected, the collection is complex, or output abruptly decreases and there is concern for catheter clogging. The presence of persistent fever or lack of clinical improvement recommends repeat imaging to assess for residual fluid or a new collection [24]. The body can wall off the drain from the rest of the abscess, or the complexity of the abscess can preclude complete drainage. In these instances manipulation of the drain to lyse adhesions or placement of a second drain can be considered. Use of persistent drain output prompts repeat imaging to assess for fistulae to bowel, which may include a tube sinogram under fluoroscopy.

Complications

Complications of PD may take place at the time of the procedure or in a delayed manner, as a result of catheter presence. Severe complications occur most commonly at the time of drain placement and include a drug-related allergic reaction or cardiac arrest/respiratory failure due to oversedation. Spread of infection to adjacent compartments or organs may occur as a delayed complication, particularly if care is not taken to avoid crossing the pleural space, for example. During transhepatic abscess drainage, careful evaluation under fluoroscopy for fistula formation to bile ducts or vascular structures is important prior to drain removal [16]. Minor complications include catheter kinking, obstruction, or dislodgement after placement. Catheter replacement depends on the clinical status of the patient and the presence of residual collection.

Bleeding is a risk of variable magnitude which depends on the location of the abscess. Abscesses within or adjacent to vascular organs, such as liver or spleen, carry a higher risk of bleeding. Proximity to vascular structures in the pelvis may increase the risk of bleeding during catheter placement. In the setting of venous injury, catheter upsize or temporary capping of the drain serves to tamponade the bleed and typically results in resolution. Persistent or pulsatile bleeding is suggestive of an arterial injury, which is assessed by CT angiography and treated by fluoroscopic angiography with embolization of the bleeding vessel. Large vessel laceration requires urgent surgical management.

Transient bacteremia has been reported in up to 5% of cases, likely related to hypervascularity in the wall of the abscess [29]. When multiple fluid collections are present and there is question as to the potential sterility of one or more, it is important to use new sterile materials for accessing and draining each collection to avoid spread of infection from one to the other [30]. Local skin infections can occur if a drainage catheter is present for a prolonged period of time. Treatment may either be with antibiotic therapy or placement of a new drain away from the infected incision.

Malposition of the catheter during placement is another risk and most commonly involves the placement of a drain into bowel. This may be immediately recognized at the time of the procedure or may be identified after persistent drain output is noted. Diagnosis may be by repeat imaging or by fluoroscopic tube evaluation. Management of an abscess drain in the bowel is either by surgical repair or delayed catheter removal after tract maturation.

Conclusion

Percutaneous drainage of abdominal abscesses has become a frequently used and valuable alternative to open surgical intervention, with similar outcomes in clinical improvement and lower morbidity and mortality. With appropriate consideration for potential risks, the procedure can be performed in conjunction with interval appendectomy to optimize outcomes in this patient population.

Clinical Pearls

- Coagulation studies are not routinely needed prior to percutaneous drainage.
- MRI and US can be used to evaluate postoperative abscess collections instead of CT avoiding unnecessary ionizing radiation.
- Transrectal abscess drainage in the deep pelvis is often better tolerated than transgluteal drains.

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