American College of Radiology
ACR Appropriateness Criteria®

Clinical Condition: **Radiologic Management of Infected Fluid Collections**

Variant 1: **Young adult patient (20-40 years of age) presents with a 7-day history of right lower quadrant abdominal pain, fever, and leukocytosis. Physical examination shows no peritoneal signs. CT scan shows a thin-walled, 3 x 4 cm fluid collection adjacent to the cecum, nonvisualization of the appendix, and an appendicolith. Highly suspicious for appendicitis. Treatment includes antibiotics.**

Treatment/Procedure	Rating	Comments
Percutaneous catheter drainage (PCD) only	7	
PCD followed by delayed surgery	6	
Needle aspiration	4	If there is no response to antibiotics.
Conservative management only	3	
Immediate surgical drainage	2	
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate		

Variant 2: **Elderly patient (more than 70 years of age) with a history of left hemicolectomy 2 months ago for colon carcinoma presents with abdominal pain and fever 2 weeks after placement of a 12-French drain into a complex, 5 cm abdominal fluid collection. Catheter output is 25 cc per day, and the collection is unchanged in size by CT. No fistula. Complex, purulent collection. Treatment includes antibiotics. Next step.**

Treatment/Procedure	Rating	Comments
Catheter upsizing	7	Depends on viscosity of fluid.
Intracavitary thrombolytic therapy and drainage	6	Commonly used, but evidence is lacking.
Laparoscopic drainage	5	When clinical response to second-line therapy PCD is incomplete.
Open surgical drainage	5	When clinical response to second-line therapy PCD is incomplete.
Continued antibiotics and drainage	3	
Continued antibiotics and drain removal	1	
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate		

Clinical Condition: **Radiologic Management of Infected Fluid Collections**

Variant 3: **Young adult patient (20-40 years of age) who is an IV drug-abuser presents with fever and tachycardia and is found to have two noncommunicating splenic abscesses measuring 4 cm in diameter and accessible percutaneously through a 1 cm rim of normal splenic tissue. Appropriate management includes antibiotics.**

Treatment/Procedure	Rating	Comments
Percutaneous catheter drainage (PCD) only	7	Second-line therapy.
Splenectomy	6	If PCD fails or is complicated.
Needle aspiration	5	To aspirate and hone antibiotic therapy if surgical risk is too high.
Conservative management only	3	
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate		

Variant 4: **Middle-aged patient (40-60 years of age) presents with abdominal pain radiating to the back 5 weeks after hospitalization for acute pancreatitis. Patient is afebrile. CT scan shows a 5 cm walled-off collection in the body of the pancreas indenting a broad portion of the body of the stomach. The collection is percutaneously accessible with a 3 cm window. MRCP shows a patent pancreatic duct.**

Treatment/Procedure	Rating	Comments
Endoscopic cystgastrostomy	8	Depends on availability of skilled endoscopist.
Percutaneous catheter drainage (PCD) only	6	
Surgical cystenterostomy	5	
Conservative management only	3	
Percutaneous needle aspiration	3	As a diagnostic tool to demonstrate that the symptoms are related to the pseudocyst.
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate		

Variant 5: **Middle-aged patient (40-60 years of age) presents with a 2-week history of cough, fever, and foul-smelling sputum. Worsening despite a full course of broad-spectrum antibiotics. Sputum cultures were negative. CT scan shows a 4 cm fluid collection in the lower lobe of the right lung.**

Treatment/Procedure	Rating	Comments
Percutaneous catheter drainage (PCD) only	7	
Surgery	4	If drainage fails.
Another course of antibiotics and postural drainage	3	
Needle aspiration	3	May help target antibiotic therapy but not as a primary therapy.
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate		

Clinical Condition: **Radiologic Management of Infected Fluid Collections**

Variant 6: **Young adult female patient (20-40 years of age) presents with abdominal pain, fever, and leukocytosis. Pelvic examination shows marked tenderness. CT scan shows a 4 cm walled-off probable tubo-ovarian abscess (TOA), safely accessible from the transgluteal, transvaginal, and transrectal approaches. Appropriate first-line treatment includes antibiotics.**

Treatment/Procedure	Rating	Comments
Transvaginal PCD	7	Transvaginal vs transgluteal determined on a case-by-case basis. Depends on expertise and patient preference.
Transgluteal PCD	7	Transvaginal vs transgluteal determined on a case-by-case basis. Depends on expertise and patient preference.
Transvaginal needle aspiration	6	Transvaginal vs transgluteal determined on a case-by-case basis. Depends on expertise and patient preference.
Transgluteal needle aspiration	6	Transvaginal vs transgluteal determined on a case-by-case basis. Depends on expertise and patient preference.
Conservative management only	5	TOAs may resolve with antibiotics, but are often treated more aggressively in young patients to preserve fertility. Some will resolve with conservative management and antibiotics. Literature is unclear.
Surgical/laparoscopic drainage	4	When drainage routes or other techniques are difficult or have failed.
Transrectal needle aspiration	3	Could lead to superinfection. Only if other approaches are not reasonable.
Transrectal PCD	3	
Rating Scale: **1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate**		

RADIOLOGIC MANAGEMENT OF INFECTED FLUID COLLECTIONS

Expert Panel on Interventional Radiology: Jonathan M. Lorenz, MD[1]; Charles E. Ray, Jr, MD, PhD[2]; Charles T. Burke, MD[3]; Michael D. Darcy, MD[4]; Nicholas Fidelman, MD[5]; Frederick L. Greene, MD[6]; Eric J. Hohenwalter, MD[7]; Thomas B. Kinney, MD[8]; Kenneth J. Kolbeck, MD[9]; Jon K. Kostelic, MD[10]; Brian E. Kouri, MD[11]; Ajit V. Nair, MD[12]; Charles A. Owens, MD[13]; Paul J. Rochon, MD[14]; Don C. Rockey, MD[15]; George Vatakencherry, MD.[16]

Summary of Literature Review

Diagnosis and Treatment of Fluid Collections

Detection and evaluation of fluid collections are typically accomplished with computed tomography (CT) and/or ultrasound (US) in patients who manifest signs and symptoms of possible infection or clinical impairment. Routine imaging of postoperative patients should be discouraged, as postoperative fluid collections are commonly present and may not be infected [1]. Expense and availability limit magnetic resonance imaging (MRI) for this purpose. US is fast, avoids ionizing radiation, and provides more detailed evaluation of the internal structure and composition of complex collections. US is more limited in the evaluation of collections deep within the soft tissues or adjacent to loops of bowel than CT or MRI, and it fails to penetrate intracavitary, pulmonary, or enteric gas. Therefore, US is more commonly used to screen for superficial or large fluid collections and collections within or adjacent to solid organs. CT provides the advantage of detecting deep collections and the use of intravenous (IV) and oral contrast to distinguish collections from adjacent vasculature or bowel. CT is usually the first-line modality in patients with fever of unknown origin. Multidetector CT scanners with sagittal and coronal reformatting can help distinguish collections from adjacent structures.

The choice of imaging guidance for draining fluid collections varies with availability, operator expertise, body habitus, presence of adjacent structures, size and location of the collection, and presence of intracavitary or enteric gas. The choice of treatment options for a given collection may vary among operators and depends on size, location, and clinical presentation. Options include antibiotics coupled with supportive measures such as bowel rest and hyperalimentation, needle aspiration for drainage or to hone antibiotic coverage, percutaneous catheter drainage (PCD), PCD with sclerotherapy, PCD with thrombolytic therapy, endoscopic drainage, immediate surgery, or delayed surgery.

Two basic techniques are available for PCD: Seldinger and trocar. For percutaneous aspiration and drainage, success thresholds of 95% and 85% have been recommended [2]. Choice of technique is primarily operator dependent, though the trocar technique has been advocated for endocavitary drain placement to avoid the risk of loss of access during the process of serial dilation — a complication associated with the Seldinger technique.

Fluid Collections in the Abdomen

Abdominal abscesses are most often the result of diverticulitis, appendicitis, Crohn's disease, and recent laparotomy. When possible, open surgical drainage (OSD) is avoided due to a high rate of morbidity and mortality [3,4]. For the management of small (<3 cm) collections, most authors advocate a trial of antibiotics alone with consideration given to needle aspiration to hone antibiotic coverage for persistent cases [5,6]. This approach uses follow-up imaging and repeat aspiration if the collection does not resolve. PCD is advocated for larger collections. Peritoneal signs, active hemorrhage, and lack of maturation of the abscess wall have been suggested as contraindications to PCD [7]. The highest success rates have been achieved for abscesses resulting from recent laparotomy [8-10], and as a result, PCD with antibiotics is usually the only treatment required for this entity.

[1]Principal Author and Panel Vice-chair, University of Chicago Hospital, Chicago, Illinois. [2]Panel Chair, University of Colorado Denver and Health Sciences Center, Aurora, Colorado. [3]University of North Carolina Hospital, Chapel Hill, North Carolina. [4]Mallinckrodt Institute of Radiology, Saint Louis, Missouri. [5]University of California-San Francisco, San Francisco, California. [6]Carolinas Medical Center, Charlotte, North Carolina, American College of Surgeons. [7]Froedtert & The Medical College of Wisconsin, Milwaukee, Wisconsin. [8]University of California-San Diego Medical Center, San Diego, California. [9]Oregon Health and Science University, Portland, Oregon. [10]Central Kentucky Radiology, Lexington, Kentucky. [11]Wake Forest University Baptist Medical Center, Winston-Salem, North Carolina. [12]Kaiser Permanente Modesto Medical Center, Modesto, California. [13]University of Illinois College of Medicine, Chicago, Illinois. [14]University of Colorado Denver, Denver, Colorado. [15]University of Texas Southwestern Medical School, Dallas, Texas, American Gastroenterological Association. [16]Kaiser Permanente, Los Angeles Medical Center, Los Angeles, California.

Reprint requests to: Department of Quality & Safety, American College of Radiology, 1891 Preston White Drive, Reston, VA 20191-4397.

For mature abscesses associated with Crohn's disease, an initial combination of PCD, antibiotics, high-dose steroids, bowel rest, and (on occasion) hyperalimentation has been advocated [11] to reduce the failure rate of PCD, temper the acute infection, and allow for surgical resection under more sterile, elective conditions. Some patients (33%-50%) will ultimately require surgical drainage or resection [12,13], but most authors still advocate a first-line trial of PCD if technically possible. In a study of 25 patients with Crohn's disease, PCD performed an average of 37 days before surgery significantly reduced the rate of severe, postoperative septic complications such as anastomotic leak, intra-abdominal abscess, and fistula [14].

For mature abscesses associated with appendicitis, an initial combination of PCD, antibiotics, bowel rest, and (on occasion) hyperalimentation has been advocated for the same reason. Some disagreement exists in the literature regarding the need for subsequent ("interval") appendectomy after successful PCD [15]. In a study of 1,012 patients with appendicitis, Kaminski et al [15] evaluated the need for PCD and the subsequent need for interval appendectomy after successful PCD. On initial presentation, the vast majority of patients with appendicitis required emergent surgery. If nonoperative management was successful, 80% of patients were cured without surgery. The push for conservative management, including PCD, rather than acute appendectomy for patients with appendicitis complicated by abscess or phlegmon is supported by a meta-analysis of 1,572 patients in 17 studies showing significant reductions in complication rates [16].

Fluid Collections in the Pelvis

Depending on location, pelvic fluid collections can be drained via the transabdominal, transgluteal, transrectal, transvaginal, and transperineal routes. The efficacy and safety of these routes have been established by a number of retrospective reports [17-21]. The choice of route for a given abscess varies among operators and institution type, with transrectal and transvaginal approaches used much more commonly in academic centers [22]. In general, reports have advocated the use of the most sterile route possible when aspirating or draining a potentially sterile collection. Using this rationale, the transabdominal and transgluteal routes would be preferable to the endocavitary routes for a potentially sterile collection. The transperineal route is most commonly used in patients after low anterior resection for rectal cancer [21]. Some disagreement exists in the literature regarding the level and incidence of significant or persistent pain when comparing the transgluteal and endocavitary routes. At a minimum, conscious sedation is required for these procedures. The route of transgluteal drainage through the greater sciatic foramen should be medial to the sciatic nerves and below the level of the periformis muscle to prevent the complications of persistent pain [18] or injury to the gluteal arteries.

For tubo-ovarian abscesses, some disagreement exists in the literature regarding the appropriate treatment. Many resolve with antibiotics and supportive care, but more recently, early aspiration (for simple collections) and transvaginal or laparoscopic drainage (for complex collections) have been advocated to prevent prolongation of the disease and the potential associated loss of fertility [23]. A literature review showed that, for women of reproductive age desiring pregnancy, if tubo-ovarian abscess exists without intra-abdominal rupture, medical management and laparoscopic drainage within 24 hours results in pregnancy rates ranging from 32%- 63% compared to 4%-15% with medical management alone [24]. The route and method of drainage depend on operator and patient preference as well as individual anatomic considerations.

For prostatic abscesses, the longstanding treatment method has been transurethral drainage, but recent small studies have demonstrated that guidance of needle aspiration or placement of small-bore pigtail catheters using transrectal US can shorten hospital stay [25] and provide a viable alternative.

Fluid Collections of the Solid Organs

Hepatic abscesses may be treated differently depending on their size and etiology. Pyogenic abscesses most often result from portal venous seeding of diverticulitis and appendicitis, but they also may occur from obstruction of the biliary system, including the gallbladder. Pyogenic abscesses complicate 1.4% of hepatic artery embolization (HAE) procedures [26]. Morbidity and mortality from pyogenic abscess may be increased in patients undergoing HAE who have a history of bilioenteric anastomosis or an incompetent sphincter of Oddi. For pyogenic abscesses <3 cm in diameter, authors have advocated using antibiotics, either alone or in conjunction with needle aspiration [27,28], with excellent success rates. For pyogenic abscesses >4-5 cm in diameter, PCD is often required. Amebic abscesses have been shown to respond extremely well to antibiotics without intervention, regardless of size [29,30], but occasionally they require needle aspiration [27].

Splenic abscesses were considered to be surgical cases as recently as the 1990s, but a number of small, retrospective series [31,32] have readdressed this issue, some advocating the benefits of PCD for solitary, simple

collections and splenectomy for multiple collections. In a retrospective study of 18 children with splenic abscesses, IV antibiotics were administered to all patients, and 10 underwent PCD for the inclusionary threshold of an abscess diameter >3 cm. Clinical response was 100% [33]. Preservation of splenic function is maintained by the use of PCD techniques, and this should be attempted where possible and safe. Current data are relatively sparse, and some disagreement exists.

A significant amount of confusing terminology is used when discussing pancreatitis, including acute and subacute fluid collections. Operators are urged to adhere to standards such as the Atlanta Criteria when describing such collections [34,35]. Pancreatic pseudocysts may resolve spontaneously if they are small, stable, and sterile. Drainage is generally advocated for large (≥5 cm), rapidly enlarging, painful, obstructing, or infected pseudocysts. Techniques for drainage are multidisciplinary [36,37], and continued disagreement of the optimal use of these techniques leads to a variety of treatment algorithms for these patients. Treatment options include endoscopic drainage with or without creation of a cystenterostomy, surgical drainage with or without creation of a cystenterostomy, and PCD. PCD generally requires a prolonged period of drainage in these patients compared to abscesses in other locations, but high rates of eventual success have been reported [37]. Complete occlusion of the main pancreatic duct central to the pseudocyst may lead to failure of PCD and necessitate use of surgical or endoscopic marsupializaton to bowel.

Pancreatic abscesses are associated with a high rate of mortality and are drained emergently. For suboptimal surgical candidates, minimally invasive alternatives include endoscopic drainage or PCD [37-40]. PCD is typically used as a temporizing measure prior to surgery, since cure rates range from 14 to 32% [38,40-42]. High rates of clinical success have been reported using endoscopic techniques [39,43], which may be optimal for more central collections and those abutting the greater curvature of the stomach. Large, complex collections involving the tail of the pancreas or not in direct communication with the pancreas may be better treated by PCD.

Renal abscesses may be cured by medical treatment in over half of cases [44], even up to 64% [45], and both renal and perirenal abscesses may otherwise require PCD, surgical drainage, or nephrectomy.

Fluid Collections in the Chest

Parenchymal lung abscesses most often occur from aspiration of anaerobic oropharyngeal bacteria or from fungal organisms. Alcoholics, immune-compromised patients, and patients with bronchial obstruction are predisposed. The organism is usually determined by culture of sputum or blood and, less optimally, by culture of cavitary fluid obtained by needle aspiration or bronchoscopy. The majority (typically >80%) is treated to resolution with antibiotics and conservative management [46]. PCD and surgical resection/drainage are generally reserved for cases that persist or worsen despite antibiotics [47-50]. Empyemas are typically drained by PCD if they are focal or uniloculated, and by surgical chest tube placement if they are multiple, multiloculated, complex, and extensive. Persistent, complex collections and organizing hemothoraces have been successfully treated with instillation of fibrinolytic agents [51]. Communication to the bronchial tree in the form of a bronchopleural fistula may require prolonged catheter drainage with the catheter placed to suction water seal.

Persistent, large, malignant, and benign pleural effusions have been successfully treated or managed with pleurodesis through small-bore catheters [52] or permanent drainage catheters with one-way valves to prevent pneumothorax [53].

Mediastinal abscesses are most commonly the result of thoracic surgical procedures, and usually require PCD. Though these cases may be technically challenging, limited studies show low complication rates, technical success approaching or reaching 100%, and clinical success exceeding 90% without the need for surgery [54].

Fluid Collections Refractory to Percutaneous Catheter Drainage

Persistence of fluid collections despite PCD may be the result of factors such as complex loculations and septations; fistulization of the cavity to the enteric, biliary, genitourinary, pancreatic, or bronchial systems; the presence of neoplastic tissue; and communication of the cavity to the lymphatic system. Depending on the reason for incomplete drainage, options may include catheter manipulation, catheter upsizing, diversion of upstream obstructions, or surgical drainage — both open and laparoscopic [55]. Fibrinolysis of complex, multiseptated fluid collections refractory to PCD by intracavitary instillation of fibrinolytic agents such as tissue plasminogen activator has been reported [51,56].

Available reports are limited in number and often small, but high rates of clinical success have been demonstrated retrospectively for abdominal and pelvic abscesses [56] as well as organizing hemothorax and empyema [51].

Case reports have even demonstrated success in the fibrinolytic treatment of refractory, complex splenic abscesses [57]. In a prospective study of 100 patients with abdominal abscesses randomized to regular instillation of sterile saline versus urokinase during catheter drainage, the urokinase group had no increase in complication rate but showed a reduction in hospital stay, drainage duration, and overall cost of treatment [58]. In a similar though smaller prospective, randomized study of 20 patients with complicated intra-abdominal abscesses, patients receiving intracavitary alteplase showed a 72% clinical success rate compared to 22% for patients receiving sterile saline [59]. Rates of bleeding complications using intracavitary recombinant tissue plasminogen activator (r-tPA) have been low to zero for pelvic, abdominal, and chest collections, except for a 33% rate of pleural hemorrhage noted for intrapleural r-tPA for patients on anticoagulation [51].

For persistent sterile collections such as cysts, lymphoceles, and seromas, a number of reports describe high rates of success in shortening the period of catheterization by intracavitary instillation of sclerotherapy agents such as ethanol or tetradecyl sulfate [60]. For cases of fistulization of the abscess cavity to enteric, biliary, genitourinary, pancreatic, or bronchial systems, PCD may be successful with prolonged catheterization [61-63].

PCD of an infected or fluid-filled tumor may be inadvertent or intentional. For good surgical candidates, tumor resection is typically performed. For poor surgical candidates, the period of catheterization may be markedly prolonged or indefinite [23,64]. Despite this finding, patients with infected, inoperable tumors at risk for systemic infection may opt for PCD.

On occasion, PCD fails to resolve the associated fluid collection despite these measures. In such circumstances, the benefit of PCD may be to limit the hematogenous or local spread of infection and improve the acute clinical presentation, thereby preparing the patient for a more elective, single-step surgical procedure. This treatment algorithm has been described for appendicitis and Crohn's disease [12].

Summary

- CT and US are the most common modalities used to diagnose and guide PCD of fluid collections. US provides more detailed evaluation of complex collections and excellent evaluation of the solid organs, but is more limited in the evaluation of collections deep within the soft tissues, adjacent to loops of bowel, or behind or containing gas. CT provides better detection of deep collections, distinction from adjacent vasculature or bowel, and more complete evaluation of patients with fever of unknown origin.
- Abdominal abscesses are typically drained with PCD if they are large (>4-5 cm), mature, and not associated with peritonitis or active hemorrhage. Imaging immediately after drainage will allow determination if additional catheters are necessary, as all collections should be preferably drained at the initial setting unless lack of a safe pathway precludes such an approach.
- Pelvic collections may be drained using multiple routes of access, including transabdominal, transgluteal, transperineal, and endocavitary. Sterile routes are more appropriate for potentially sterile collections.
- Collections may be refractory to PCD in cases of fistula formation, complex internal structure, the presence of neoplastic tissue, or communication to the lymphatic system. Depending on the cause, treatment options include prolonged catheterization, catheter manipulation or upsizing, diversion of upstream obstruction, bowel rest, instillation of fibrinolytic agents, instillation of sclerotherapy agents, and surgical drainage.
- PCD has been applied to splenic and pancreatic abscesses with variable results and recommendations in the literature, suggesting that the best current approach is multidisciplinary, depending on the extent and location of disease.
- Smaller abscesses and abscesses of the kidney and lung parenchyma have a high rate of clinical response to antibiotic therapy and supportive care, with more invasive treatments typically reserved for extensive or refractory cases.

Supporting Documents

- ACR Appropriateness Criteria® Overview
- Evidence Table

References

1. Neff CC, Simeone JF, Ferrucci JT, Jr., Mueller PR, Wittenberg J. The occurrence of fluid collections following routine abdominal surgical procedures: sonographic survey in asymptomatic postoperative patients. *Radiology.* 1983;146(2):463-466.
2. Bakal CW, Sacks D, Burke DR, et al. Quality improvement guidelines for adult percutaneous abscess and fluid drainage. *J Vasc Interv Radiol.* 2003;14(9 Pt 2):S223-225.
3. Olak J, Christou NV, Stein LA, Casola G, Meakins JL. Operative vs percutaneous drainage of intra-abdominal abscesses. Comparison of morbidity and mortality. *Arch Surg.* 1986;121(2):141-146.
4. vanSonnenberg E, Mueller PR, Ferrucci JT, Jr. Percutaneous drainage of 250 abdominal abscesses and fluid collections. Part I: Results, failures, and complications. *Radiology.* 1984;151(2):337-341.
5. Kumar RR, Kim JT, Haukoos JS, et al. Factors affecting the successful management of intra-abdominal abscesses with antibiotics and the need for percutaneous drainage. *Dis Colon Rectum.* 2006;49(2):183-189.
6. Siewert B, Tye G, Kruskal J, et al. Impact of CT-guided drainage in the treatment of diverticular abscesses: size matters. *AJR Am J Roentgenol.* 2006;186(3):680-686.
7. Parc Y, Frileux P, Schmitt G, Dehni N, Ollivier JM, Parc R. Management of postoperative peritonitis after anterior resection: experience from a referral intensive care unit. *Dis Colon Rectum.* 2000;43(5):579-587; discussion 587-579.
8. Bouali K, Magotteaux P, Jadot A, et al. Percutaneous catheter drainage of abdominal abscess after abdominal surgery. Results in 121 cases. *J Belge Radiol.* 1993;76(1):11-14.
9. Cinat ME, Wilson SE, Din AM. Determinants for successful percutaneous image-guided drainage of intra-abdominal abscess. *Arch Surg.* 2002;137(7):845-849.
10. Khurrum Baig M, Hua Zhao R, Batista O, et al. Percutaneous postoperative intra-abdominal abscess drainage after elective colorectal surgery. *Tech Coloproctol.* 2002;6(3):159-164.
11. Poritz LS, Koltun WA. Percutaneous drainage and ileocolectomy for spontaneous intraabdominal abscess in Crohn's disease. *J Gastrointest Surg.* 2007;11(2):204-208.
12. Gervais DA, Hahn PF, O'Neill MJ, Mueller PR. Percutaneous abscess drainage in Crohn disease: technical success and short- and long-term outcomes during 14 years. *Radiology.* 2002;222(3):645-651.
13. Gutierrez A, Lee H, Sands BE. Outcome of surgical versus percutaneous drainage of abdominal and pelvic abscesses in Crohn's disease. *Am J Gastroenterol.* 2006;101(10):2283-2289.
14. Muller-Wille R, Iesalnieks I, Dornia C, et al. Influence of percutaneous abscess drainage on severe postoperative septic complications in patients with Crohn's disease. *Int J Colorectal Dis.* 2011;26(6):769-774.
15. Kaminski A, Liu IL, Applebaum H, Lee SL, Haigh PI. Routine interval appendectomy is not justified after initial nonoperative treatment of acute appendicitis. *Arch Surg.* 2005;140(9):897-901.
16. Simillis C, Symeonides P, Shorthouse AJ, Tekkis PP. A meta-analysis comparing conservative treatment versus acute appendectomy for complicated appendicitis (abscess or phlegmon). *Surgery.* 2010;147(6):818-829.
17. Cahill AM, Baskin KM, Kaye RD, Fitz CR, Towbin RB. Transgluteal approach for draining pelvic fluid collections in pediatric patients. *Radiology.* 2005;234(3):893-898.
18. Harisinghani MG, Gervais DA, Maher MM, et al. Transgluteal approach for percutaneous drainage of deep pelvic abscesses: 154 cases. *Radiology.* 2003;228(3):701-705.
19. Lee BC, McGahan JF, Bijan B. Single-step transvaginal aspiration and drainage for suspected pelvic abscesses refractory to antibiotic therapy. *J Ultrasound Med.* 2002;21(7):731-738.
20. Nelson AL, Sinow RM, Oliak D. Transrectal ultrasonographically guided drainage of gynecologic pelvic abscesses. *Am J Obstet Gynecol.* 2000;182(6):1382-1388.
21. Sperling DC, Needleman L, Eschelman DJ, Hovsepian DM, Lev-Toaff AS. Deep pelvic abscesses: transperineal US-guided drainage. *Radiology.* 1998;208(1):111-115.
22. Jaffe TA, Nelson RC, Delong DM, Paulson EK. Practice patterns in percutaneous image-guided intraabdominal abscess drainage: survey of academic and private practice centers. *Radiology.* 2004;233(3):750-756.
23. Fabiszewski NL, Sumkin JH, Johns CM. Contemporary radiologic percutaneous abscess drainage in the pelvis. *Clin Obstet Gynecol.* 1993;36(2):445-456.
24. Rosen M, Breitkopf D, Waud K. Tubo-ovarian abscess management options for women who desire fertility. *Obstet Gynecol Surv.* 2009;64(10):681-689.

25. Chou YH, Tiu CM, Liu JY, et al. Prostatic abscess: transrectal color Doppler ultrasonic diagnosis and minimally invasive therapeutic management. *Ultrasound Med Biol.* 2004;30(6):719-724.
26. Mezhir JJ, Fong Y, Fleischer D, et al. Pyogenic abscess after hepatic artery embolization: a rare but potentially lethal complication. *J Vasc Interv Radiol.* 2011;22(2):177-182.
27. Qin SL, Wang AX, Sheng RY, Liu ZY. [Clinical analysis of 36 cases with amebic liver abscess]. *Zhongguo Ji Sheng Chong Xue Yu Ji Sheng Chong Bing Za Zhi.* 2000;18(6):356-358.
28. Stain SC, Yellin AE, Donovan AJ, Brien HW. Pyogenic liver abscess. Modern treatment. *Arch Surg.* 1991;126(8):991-996.
29. Donovan AJ, Yellin AE, Ralls PW. Hepatic abscess. *World J Surg.* 1991;15(2):162-169.
30. Pitt HA. Surgical management of hepatic abscesses. *World J Surg.* 1990;14(4):498-504.
31. Chang KC, Chuah SK, Changchien CS, et al. Clinical characteristics and prognostic factors of splenic abscess: a review of 67 cases in a single medical center of Taiwan. *World J Gastroenterol.* 2006;12(3):460-464.
32. Tung CC, Chen FC, Lo CJ. Splenic abscess: an easily overlooked disease? *Am Surg.* 2006;72(4):322-325.
33. Choudhury SR, Debnath PR, Jain P, et al. Conservative management of isolated splenic abscess in children. *J Pediatr Surg.* 2010;45(2):372-375.
34. Bradley EL, 3rd. A clinically based classification system for acute pancreatitis. Summary of the International Symposium on Acute Pancreatitis, Atlanta, Ga, September 11 through 13, 1992. *Arch Surg.* 1993;128(5):586-590.
35. Bradley EL, 3rd. A clinically based classification system for acute pancreatitis. *Ann Chir.* 1993;47(6):537-541.
36. Giovannini M, Pesenti C, Rolland AL, Moutardier V, Delpero JR. Endoscopic ultrasound-guided drainage of pancreatic pseudocysts or pancreatic abscesses using a therapeutic echo endoscope. *Endoscopy.* 2001;33(6):473-477.
37. Lang EK, Paolini RM, Pottmeyer A. The efficacy of palliative and definitive percutaneous versus surgical drainage of pancreatic abscesses and pseudocysts: a prospective study of 85 patients. *South Med J.* 1991;84(1):55-64.
38. Mithofer K, Mueller PR, Warshaw AL. Interventional and surgical treatment of pancreatic abscess. *World J Surg.* 1997;21(2):162-168.
39. Park JJ, Kim SS, Koo YS, et al. Definitive treatment of pancreatic abscess by endoscopic transmural drainage. *Gastrointest Endosc.* 2002;55(2):256-262.
40. Rotman N, Mathieu D, Anglade MC, Fagniez PL. Failure of percutaneous drainage of pancreatic abscesses complicating severe acute pancreatitis. *Surg Gynecol Obstet.* 1992;174(2):141-144.
41. Bradley EL, 3rd, Olson RA. Current management of pancreatic abscess. *Adv Surg.* 1991;24:361-388.
42. Steiner E, Mueller PR, Hahn PF, et al. Complicated pancreatic abscesses: problems in interventional management. *Radiology.* 1988;167(2):443-446.
43. Venu RP, Brown RD, Marrero JA, Pastika BJ, Frakes JT. Endoscopic transpapillary drainage of pancreatic abscess: technique and results. *Gastrointest Endosc.* 2000;51(4 Pt 1):391-395.
44. Coelho RF, Schneider-Monteiro ED, Mesquita JL, Mazzucchi E, Marmo Lucon A, Srougi M. Renal and perinephric abscesses: analysis of 65 consecutive cases. *World J Surg.* 2007;31(2):431-436.
45. Yen DH, Hu SC, Tsai J, et al. Renal abscess: early diagnosis and treatment. *Am J Emerg Med.* 1999;17(2):192-197.
46. Moreira Jda S, Camargo Jde J, Felicetti JC, Goldenfun PR, Moreira AL, Porto Nda S. Lung abscess: analysis of 252 consecutive cases diagnosed between 1968 and 2004. *J Bras Pneumol.* 2006;32(2):136-143.
47. Ha HK, Kang MW, Park JM, Yang WJ, Shinn KS, Bahk YW. Lung abscess. Percutaneous catheter therapy. *Acta Radiol.* 1993;34(4):362-365.
48. vanSonnenberg E, D'Agostino HB, Casola G, Wittich GR, Varney RR, Harker C. Lung abscess: CT-guided drainage. *Radiology.* 1991;178(2):347-351.
49. Weissberg D. Percutaneous drainage of lung abscess. *J Thorac Cardiovasc Surg.* 1984;87(2):308-312.
50. Yellin A, Yellin EO, Lieberman Y. Percutaneous tube drainage: the treatment of choice for refractory lung abscess. *Ann Thorac Surg.* 1985;39(3):266-270.
51. Gervais DA, Levis DA, Hahn PF, Uppot RN, Arellano RS, Mueller PR. Adjunctive intrapleural tissue plasminogen activator administered via chest tubes placed with imaging guidance: effectiveness and risk for hemorrhage. *Radiology.* 2008;246(3):956-963.

52. Marom EM, Patz EF, Jr., Erasmus JJ, McAdams HP, Goodman PC, Herndon JE. Malignant pleural effusions: treatment with small-bore-catheter thoracostomy and talc pleurodesis. *Radiology.* 1999;210(1):277-281.
53. Warren WH, Kalimi R, Khodadadian LM, Kim AW. Management of malignant pleural effusions using the Pleur(x) catheter. *Ann Thorac Surg.* 2008;85(3):1049-1055.
54. Arellano RS, Gervais DA, Mueller PR. Computed tomography-guided drainage of mediastinal abscesses: clinical experience with 23 patients. *J Vasc Interv Radiol.* 2011;22(5):673-677.
55. Kok KY, Yapp SK. Laparoscopic drainage of postoperative complicated intra-abdominal abscesses. *Surg Laparosc Endosc Percutan Tech.* 2000;10(5):311-313.
56. Beland MD, Gervais DA, Levis DA, Hahn PF, Arellano RS, Mueller PR. Complex abdominal and pelvic abscesses: efficacy of adjunctive tissue-type plasminogen activator for drainage. *Radiology.* 2008;247(2):567-573.
57. Statler JD, Doherty RD, McLaughlin JJ, Gleason JD, McDermott MP. Tissue plasminogen activator in the percutaneous drainage of splenic abscess. *J Vasc Interv Radiol.* 2010;21(2):307-309.
58. Laborda A, De Gregorio MA, Miguelena JM, et al. Percutaneous treatment of intrabdominal abscess: urokinase versus saline serum in 100 cases using two surgical scoring systems in a randomized trial. *Eur Radiol.* 2009;19(7):1772-1779.
59. Cheng D, Nagata KT, Yoon HC. Randomized prospective comparison of alteplase versus saline solution for the percutaneous treatment of loculated abdominopelvic abscesses. *J Vasc Interv Radiol.* 2008;19(6):906-911.
60. Demir E, Alan C, Kilciler M, Bedir S. Comparison of ethanol and sodium tetradecyl sulfate in the sclerotherapy of renal cyst. *J Endourol.* 2007;21(8):903-905.
61. Do H, Lambiase RE, Deyoe L, Cronan JJ, Dorfman GS. Percutaneous drainage of hepatic abscesses: comparison of results in abscesses with and without intrahepatic biliary communication. *AJR Am J Roentgenol.* 1991;157(6):1209-1212.
62. Schuster MR, Crummy AB, Wojtowycz MM, McDermott JC. Abdominal abscesses associated with enteric fistulas: percutaneous management. *J Vasc Interv Radiol.* 1992;3(2):359-363.
63. Wittich GR. Radiologic treatment of abdominal abscesses with fistulous communications. *Curr Opin Radiol.* 1992;4(4):110-115.
64. Mueller PR, White EM, Glass-Royal M, et al. Infected abdominal tumors: percutaneous catheter drainage. *Radiology.* 1989;173(3):627-629.