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REVIEW

R. Golfieri • A. Cappelli

Computed tomography-guided percutaneous abscess drainage in coloproctology: review of the literature

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Abstract Background Percutaneous abscess drainage (PAD) of the lower abdomen and pelvis has been reported to reduce morbidity and mortality, shorten hospital stay and cut costs compared to a surgical approach. However, the wide differences in outcome reported by different authors indicate the need for an overview and further evaluations. This review evaluates each point of the procedure to explain the possible causes for such discrepancies in results. **Methods** We performed a PubMed search of outcomes for percutaneous abscesses drainage, focusing on deep pelvic collections, which represent the most difficult task, searching among papers published from 1981 to 2006. **Results** Ninety-nine papers were selected. Most authors emphasized that the most important steps of the care process are: (a) patient selection; (b) indications and contraindications; (c) choice of the best access route; (d) procedure performance; and (e) outcome (success and complication rates). **Conclusions** PAD is a safe and effective alternative to surgery for draining deep infected fluid collections, with a higher success rate, lower complication rate and shorter hospital stay compared to surgical drainage. Meticulous technique and careful access planning seem to be the two most important factors affecting the outcome.

Key words Abscess • Percutaneous drainage • Pelvic organs • Interventional procedures • Crohn's disease

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Introduction

Percutaneous abscess drainage (PAD) is defined as positioning a catheter under imaging guidance and maintaining it in place to provide continuous drainage of a fluid collection. Percutaneous aspiration is the simple evacuation of a fluid collection using either catheter or needle, followed by removal of the catheter or needle immediately after the aspiration.

Nowadays, PAD is considered the standard therapy for intra-abdominal and pelvic infected fluid collections. A wide variety of disorders may lead to infected fluid collection formation in the lower abdomen and pelvis, such as: (1) intestinal perforation (secondary to appendicitis, diverticulitis, neoplastic lesions); (2) inflammatory bowel diseases such as Crohn's disease (CD); (3) septic surgical complications due to anastomotic dehiscence, hematoma, abscess, seroma, lymphocele, urinoma; and (4) pelvic inflammatory diseases such as tubo-ovarian abscesses.

Most of these abscesses can be drained percutaneously, but a minority of fluid collections may be initially "undrainable" because of their location (near vital structures) or the dense consistency of their contents.

The most important factors conditioning the effectiveness of PAD, namely for "inaccessible" or "undrainable" collections, are:

- Abscess characteristics: etiology, location and close proximity to vital structures, size and number of collections, presence of fistulas;
- Patients' clinical conditions (APACHE score);
- Choice of the most appropriate access route;
- Choice of the most appropriate percutaneous procedure (simple aspiration or continuous external drainage to obtain a complete evacuation).

The development of computed tomography (CT) in the 1970s led to the use of CT-guided drainage of deep abscesses, and several studies have demonstrated its safety and efficacy. Therefore, percutaneous drainage of infected pelvic fluid collections under CT guidance has been recommended by the Society of Cardiovascular and Interventional Radiology since 1995 as a good alternative to surgical drainage prior to elective surgical treatment [1]. Advantages are well documented also in the surgical literature, indicating PAD as the primary mode of treatment and standard of care for intra-abdominal abscesses.

We reviewed the effective use of CT-guided PAD and evaluated not only the most important criteria for abdominal and pelvic abscess percutaneous drainage, but also the highly variable success rates reported by different authors. The article was designed to review the current criteria governing the correct approach to the procedure and the clinical impact of CT-guided PAD in the management of abdominal and pelvic abscesses.

Materials and methods

Studies were retrieved back to 1981 (twenty-five years) through MEDLINE on the PubMed database using the key words "abscess, percutaneous drainage", "pelvic organs, abscess", "pelvic organs, interventional procedures", "Crohn's disease, percutaneous drainage", "abdominal interventional procedures" and "review", and by a manual search and review of reference lists.

The present review only considered papers published in English, taking into account each journal's range of influence (impact factor and citation index), focusing on the most important steps in the care process including the following: (a) patient selection; (b) indications and contraindications; (c) choice of the best access route; (d) procedure performance; and (e) outcome (success and complication rates).

Results

The search identified a total of 99 papers, published in radiological (62%), surgical (30%), gynecological (1%), and gastroenterological (7%) journals. Among these, 17 (Table 1) compared different results between PAD and surgical drainage while 47 (Table 2) evaluated specifically the outcome of PAD, CT or US guided, for deep pelvic and abdominal abscesses. The most important reports published on PAD in CD were also included.

Table 1 Studies comparing CT-guided PAD to surgical drainage

Reference	Patients, *n*		Success rate, %		Mortality, %	
	Percutaneous drainage	Surgical drainage	Percutaneous drainage	Surgical drainage	Percutaneous drainage	Surgical drainage
Johnson et al. (1981) [8]	27	43	89	70	11	21
Halasz, van Sonnemberg (1983) [9]	11	19	NR	NR	9	16
Aeder et al. (1983) [10]	13	32	69	NR	23	37
Brolin et al. (1984) [11]	24	24	92	88	0	13
Glass, Cohn (1984) [12]	15	44	47	88	NR	NR
Olak et al. (1986) [2]	27	27	70	85	11	7
Lurie et al. (1987) [13]	29	60	80	81	17	17
Malangoni et al. (1990) [14]	18	30	61	53	11	27
Hemming et al. (1991) [3]	42	41	93	96	12	14
Levison, Zeigler (1991) [15]	57	54	47	54	29	29
Lang et al. (1991) [4]	41	41	NR	NR	16	33
Bufalari et al. (1996) [6]	27	10	NR	NR	11	20
Ayuk et al. (1996) [17]	14	30	37.5	76.7	NR	NR
Giangreco et al. (1997) [5]	32	39	72.7	62.5	7	NR
Jawhari et al (1998) [18]	15	28	26.6	NR	NR	NR
Garcia et al. (2001) [16]	18	30	61	53	11	27
Guiterrez et al. (2006) [7]	37	29	75.6	82.7	0	0

NR, not reported

Table 2 Studies evaluating the percutaneous treatment of abscesses

Reference	Abscesses, *n* (patients, *n*)	Diagnosis	Access route	Guidance		Success, %	Mortality, %	Complications, %	Recurrence, % (months)	Mean drainage, days
				CT	US					
Gerzof et al. (1981) [20]	71 (67)	AA	NR	Y	Y	86	8.4	15	1 (22.3)	20.2
VanSonnenberg et al. (1982) [79]	58 (51)	AA, PA	NR	Y	Y	85	0	8.6	10.9	7
VanSonnenberg et al. (1984) [22]	250 (212)	AA	NR	Y	N	83.6	0	10.4	8	0
Mueller et al. (1984) [83]	8 (8)	IA	NR	Y	N	87.5	0	0	0	0
Mueller et al. (1985) [45]	12 (12)	PLSA	TH	Y	N	100	0	0	NR	NR
Johnson et al. (1985) [82]	23 (23)	LA	TH	Y	N	76	0	0	0	0
Jaques et al. (1986) [40]	71 (53)	AA	NR	Y	N	84	NR	NR	NR	NR
Lang et al. (1986) [80]	136 (136)	AA	NR	Y	Y	97.7	1.4	5	NR	NR
Butch et al. (1986) [62]	21 (21)	PA	TG	Y	N	81	0	0	NR	NR
Casola et al. (1987) [41]	15 (15)	CD	NR	Y	N	80	0	0	0	15
VanSonnenberg et al. (1987) [87]	21 (21)	PPA	NR	Y	N	90.4	NR	NR	NR	8
Mueller et al. (1987) [58]	24 (24)	PA	NR	Y	N	NR	NR	NR	NR	NR
Nosher et al. (1987) [76]	2 (2)	PA	TV	N	Y	100	NR	NR	NR	NR
Safrit et al. (1987) [93]	18 (10)	CD	NR	N	N	NR	NR	NR	NR	NR
Steiner et al. (1988) [84]	25 (25)	PancA	NR	Y	N	32	NR	NR	NR	NR
Lambiase et al. (1988) [94]	9 (8)	CD	NR	N	N	NR	NR	NR	NR	NR
VanSonnenberg et al. (1989) [86]	101 (101)	PancA	NR	Y	Y	90.1	0	13	0	19.6
Lang et al. (1990) [42]	33 (33)	RA	NR	N	N	NR	NR	NR	NR	NR
Tyrrel et al. (1990) [85]	8 (8)	PA	NR	Y	N	88	NR	NR	12.5 (20)	6
Gazelle et al. (1991) [66]	10 (10)	PA	TR	Y	N	100	NR	NR	NR	6.9
VanSonnenberg et al. (1991) [73]	13 (13)	PA	TV	N	Y	100	NR	NR	NR	6.7
Lambiase et al. (1992) [49]	335 (323)	AA, PA	NR	Y	Y	62.4	14.2	9.8	2.1 (3)	NR
Bennett et al. (1992) [69]	8 (8)	PA	TR	N	Y	100	NR	NR	NR	3
Casola et al. (1992) [71]	27 (16)	TOA	TV	Y	Y	94	0	11.1	7.4 (3.4)	6
Bouali et al. (1993) [23]	121 (121)	AA, RPA, PA	NR	Y	Y	NR	NR	NR	NR	NR
McGahan et al. (1996) [75]	7 (7)	PA	TV	N	Y	86	NR	NR	NR	1–3*
Sahai et al. (1997) [91]	27 (24)	CD, PA	NR	Y	N	56	0	15	NR	NR
Sperling et al. (1998) [65]	12 (12)	PA	TP	N	Y	90	NR	NR	NR	40
Marano et al. (1999) [97]	83 (83)	AA	NR	Y	N	73.5	NR	NR	NR	NR
Kim et al. (1999) [55]	23 (20)	Lymphocele	NR	Y	Y	87	0	17.3	13	22
Gervais et al. (2000) [53]	7 (7)	PA	TG	Y	N	NR	NR	NR	NR	5.6
Gervais et al. (2002) [90]	32 (32)	CD, PA	NR	Y	N	96	0	3.1	22 (7.5)	15.2
Betsch et al. (2002) [29]	75 (75)	AA	NR	Y	N	83	0	5.3	NR	14
Cinat et al. (2002) [98]	92 (92)	AA	NR	Y (80%)	Y (20%)	70	0	NR	NR	14
Khurrum Baig et al. (2002) [38]	40 (40)	AA	TP, TG	Y	N	85	0	0	35	3–20*
Harinshingani et al. (2003) [57]	154 (154)	PA	TG	Y	N	96	0	2	NR	8
Rose et al. (2003) [78]	46 (26)	AA	NR	Y (3D)		77	2.1	0	0	0
Gervais et al. (2004) [92]	956 (785)	AA	NR	Y	Y	91	NR	NR	51d	Primary, 25 Secondary, 14

Cont. →

Cont. of Table 2

Reference	Abscesses, *n* (patients, *n*)	Diagnosis	Access route	Guidance CT	Guidance US	Success, %	Mortality, %	Complications, %	Recurrence, % (months)	Mean drainage, days
Benoist et al. (2004) [37]	73 (73)	AA	NR	Y	Y	81	3	0	0	0
Akinci et al. (2005) [54]	300 (255)	AA, PA	NR	Y	Y	91	NR	3.1	13	
Soyer et al. (2005) [61]	21 (21)	PA	NR	Y	N	95	0	0	NR	NR
Lee et al. (2006) [19]	24	CD	NR	Y	Y	PD 80	NR	NR	PD 12.5 (2)	NR
	(5 PD; 19 MT)					MT 63.2			MT 20	
Kumar et al. (2005) [39]	114	AA	NR	Y	Y	PD 86	NR	NR	0	NR
	(53 PD; 61 MT)					MT 59			0	
Brandt et al. (2006) [30]	66	AA	TP, TG	Y	N	PD 67	PD 8.8	PD 32.3	PD 29.4	8
	(34 PD; 32 MT)					MT 81.3	MT 3.1	MT 18.7	MT 15.6	
Mehendiratta et al. (2007) [99]	92 (92)	AA, PA	NR	Y	N	73	9	NR	NR	NR
Neufel et al. (2006) [95]	17 (13)	CD, AA	NR	Y	N	NR	NR	NR	NR	NR
Golfieri et al. (2006) [96]	87 (87)	PA	NR	Y	N	85	0	0	12.6 (6)	10.5

AA, abdominal abscess; *PA*, pelvic abscess; *PancA*, pancreatic abscess; *IA*, iliopsoas abscess; *PLSA*, peritoneal lesser sac abscess; *LA*, liver abscess; *PPA*, peri-appendiceal abscess; *RA*, renal abscess; *TOA*, tubo-ovarian abscess; *RPA*, retroperitoneal abscess; *NR*, not reported; *TH*, transhepatic; *TG*, transgluteal; *TV*, transvaginal; *TR*, transrectal; *TP*, transperitoneal; *MT*, medical therapy; *CD*, Crohn's disease; *PD*, percutaneous drainage; * range

PAD as an alternative to surgical drainage

Over the last 20 years, PAD has evolved from a revolutionary to a routine procedure, replacing open surgical drainage (OSD) in all but the most difficult or inaccessible cases. Since the early 1980s, when PAD was introduced, its effectiveness and safety have been demonstrated in retrospective and prospective studies comparing PAD to OSD (Table 1), reporting PAD as associated with a higher success rate, fewer complications and lower morbidity and mortality. Reported success rates range from 27% to 93%, complication rates are 1%–15%, and mortality rates are 7%–29%. The wide differences in results are most likely due to the heterogeneous characteristics of patients included (e.g. general clinical conditions, abscess location and morphology, presence or absence of fistula) and to the lack of prospective randomized studies comparing PAD and OSD.

Two of the major case-controlled studies reported similar data. In particular Olak et al. [2] compared PAD to OSD in 54 patients and found no significant differences in terms of mortality (11% vs. 7.4%) and morbidity (29% vs. 40%) while success rates were similar (70% vs. 85%). Hemming et al. [3] studied 83 patients and reported similar mortality and morbidity rates between PAD and OSD (12% vs. 14%, and 29% vs. 26%, respectively). PAD was successful in 93% of cases and OSD in 96%. The duration of hospital stay was also similar in the two groups, while the overall condition of patients (APACHE II scores) was the only prognostic factor for morbidity and mortality in both PAD and OSD groups [3]. The results of other case-controlled studies [4–15] vary widely, with success rates ranging from 47% to 92% since the authors assessed different guidance methods (CT or US) and abscess locations (upper abdominal fluid collections, pancreatic fluid collections, postoperative collections, etc). Lower success rates, ranging from 27% to 61%, have been historically reported in series limited to patients with CD [16–18]. However, a recent study [19] that compared two non-surgical treatments for abscesses in CD (PAD associated with medical treatment vs. medical treatment alone) reported treatment-specific success rates of 80% and 63.2%, respectively, and an overall success rate of 66.7% for non-surgical abscess treatment. Therefore, this approach was recommended for patients with CD without associated fistula or concurrent steroid use.

All these experiences confirmed PAD as a safe and valuable alternative to surgery or as a temporary therapeutic measure while planning the elective surgical treatment, emphasizing that the most important steps of the process of care are: (a) patient selection; (b) indications and contraindications; (c) choice of the best access route; (d) procedure performance; and (e) outcome (success and complication rates).

Patient selection

This analysis of the literature data failed to reveal universally accepted criteria for patient selection. General criteria are based on the most suitable size and shape of the fluid collection. Gerzof et al.'s original selection criteria

[20] indicated PAD only for the "simple abscess", defined as a unilocular, well-defined cavity whose infectious nature was diagnosed by Gram's stain and culture of fluid, obtained by pre-drainage fine needle aspiration. In this condition, the reported success rate of PAD ranged from 85% to 93%. The latest expansion of indications [21] to include "complex abscesses" (multiloculated, associated with fistulae, splenic abscesses and infected fluid collections whose drainage route traversed normal organs) demonstrated a curative rate of only 45%. Conversely, other authors reported a success rate of PAD for complex abscesses ranging from 70% to 88% [22–25]. Whether temporizing or curative, PAD is so common in interventional radiology that in 1996 the American College of Radiology (ACR) issued appropriateness criteria (subsequently revised in 1999) for the procedure [26]. Official ACR practice guidelines for procedural performance and technical standards were reported in 1995 and updated in 2003 [27, 28]. According to these revised guidelines, PAD is considered appropriate in the following conditions:

1. All simple abscesses with safe drainage routes (without involvement of organs or structures or direct contact with major blood vessels)
2. Most complex abscesses with safe drainage routes
3. Pyogenic liver abscesses when single or limited in number
4. Infected pseudocysts.

Several studies suggested that both patient and abscess characteristics may affect the outcome [5, 29] and that failure is more likely for complex abscesses.

In spontaneous abscesses, data from the literature are still controversial and the effectiveness of conservative treatment with antibiotics alone, without drainage, has been pointed out. Recently, Brandt et al. [30] in a case-control study found no benefits of CT-guided PAD in the treatment of abscesses associated with Hinchey II diverticulitis, while antibiotic therapy alone seemed to be a safe alternative. Bamberger [31], in a review found that antimicrobial therapy alone was successful in 86% of cases, with less favorable outcomes in abscesses >5 cm. Others reported the efficacy of antibiotic therapy in the treatment of postappendectomy abscesses, both in the pediatric population [32, 33] and in adults with mesocolic and pelvic diverticular abscesses [34, 35]. Ambrosetti et al. [35], in a prospective study of 140 patients with acute left-sided colonic diverticulitis, demonstrated that about 59% of cases were successfully treated with antibiotics alone and concluded that mesocolic abscesses did not always require drainage or colectomy, whereas pelvic abscesses had a much more aggressive behavior and often required surgery. The same authors more recently [36] concluded that mesocolic abscesses do not represent an indication for colectomy, since conservative management can be considered and the need for drainage is significantly high in abscesses of 5 cm or larger. Conversely, in pelvic abscesses, considering their poor outcome, drainage is required especially in larger ones, and secondary colectomy was needed significantly more frequently.

Regarding postoperative intra-abdominal abscesses, there is consensus about PAD in conjunction with antibiotics as the initial treatment [37]: Baig et al. [38] used PAD to treat intra-abdominal abscesses following elective colorectal surgery and achieved primary and secondary success rates of 65% and 85%, respectively. Kumar et al. [39] showed that conservative treatment of postoperative abscesses with antibiotics alone was less successful in abscesses with diameters larger than 6.5 cm and when temperature at admission was 101.2° F (38.9° C): these patients have a higher likelihood of failing conservative therapy and require PAD.

Therefore, facing patients with abscesses, the combined team of gastroenterologists, interventional radiologists and surgeons should jointly reach a consensus about the best patient-tailored treatment. Larger abscesses should be drained percutaneously whenever possible.

Indications and contraindications

Indications for PAD include an abnormal fluid collection likely to be infected, with the clinical suspicion that the collection is producing symptoms sufficient to warrant drainage and the need for fluid characterization. Usually, radiological signs will not distinguish among various types of fluid collections or predict the utility of therapeutic catheter drainage [20, 40]. The first step of PAD in all cases should be needle aspiration to determine the nature (infected versus non-infected) of the fluid collection and establish a differential diagnosis (abscess, hematoma, urinoma, biloma, lymphocele, seroma, loculated ascites, etc.). In collections <3 cm, simple diagnostic aspiration can be sufficient to evacuate the fluid content completely and PAD is usually superfluous (the "3-cm rule") (Fig. 1)

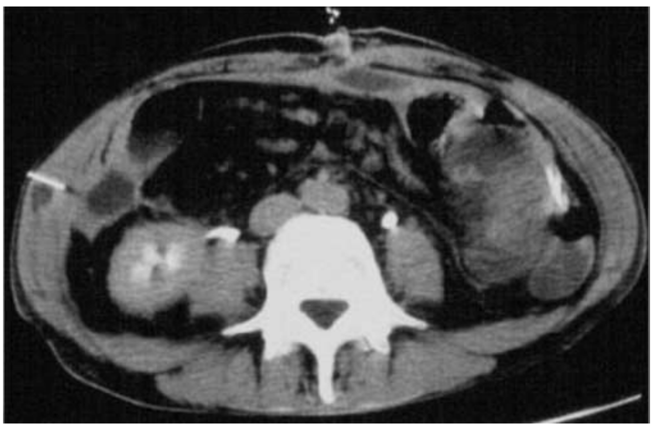

Fig. 1 Axial CT image of a thick-walled fluid collection <3 cm in diameter, considered an indication for simple diagnostic aspiration. A Chiba needle is shown approaching the abscess to collect a fluid sample for diagnostic cultures

[41]. Therefore, PAD with placement of a permanent external drainage is indicated to treat or palliate sepsis due to infected fluid collections >3 cm.

An absolute contraindication to PAD is the absence of a safe access route, at the risk of transgressing solid organs, bowel or major blood vessels. In these situations, only diagnostic needle aspiration is recommended, since solid organs (e.g. liver, kidney) and small bowel may be safely transgressed with a 20–22 gauge Chiba needle [42–45].

Relative contraindications to PAD, to be corrected or controlled before positioning, are significant coagulopathy, inability of the patient to cooperate or maintain a stable position during the procedure (anesthesia can be administered if necessary), adverse reaction to contrast media, hemodynamic instability or severe clinical conditions which cannot be controlled [20, 22, 40, 42, 46–50].

Drainage guidance method and access routes

Selection of the most appropriate guidance method among ultrasound (US), CT and fluoroscopy remains controversial. The choice should be based on both abscess location and operator skill; as a general rule, the most efficient imaging system demonstrating the location, extent, and relations of the fluid collection to vital structures should be chosen as the guidance method. Occasionally, more than one modality may be required. Real-time US is preferred when the fluid collections are superficial or clearly visualized and a safe access route can be identified. Usually, US is preferred for its ease of handling, low cost and avoidance of X-ray exposure. Sometimes the abdominal approach can be limited by the air acoustic barrier of bowel loops.

CT is considered the most effective method, both in the diagnosis and guidance of interventional procedures, for deep-seated fluid collections with overlying vital structures, although more time-consuming and involving X-ray exposure. Moreover, CT-fluoroscopy is a useful additional tool for difficult abscess drainage, while shortening the time needed for interventional radiological procedures. The X-ray exposure can be reduced for both patients and operators by modifying the scanning parameters for CT fluoroscopy, once initial CT has been performed to identify and locate the abscess [51, 52].

The selection of the most appropriate access route is a fundamental step of the procedure:

- *Transabdominal anterior approach* is still the preferred route, since it is technically the simplest, although not always practicable due to interposed bowel and other pelvic viscera [53–55]. In the anterior or lateral approach, the needle is inserted through the abdominal wall; in the anterior approach the inferior epigastric vessels, located behind the rectus abdominis muscle, should be avoided.
- *Transabdominal lateral approach* (Fig. 2) requires identification of the deep circumflex iliac vessels situated along the anterior abdominal wall near the iliac crest. As previously mentioned, transgression of bowel loops with a thin 22-gauge needle is generally considered safe, but is dangerous when performed with a large calibre (10–14 F) drainage catheter: in such cases, a safe alternative access route should be planned.
- *Transgluteal approach* through the greater sciatic foramen is an alternative approach to deep pelvic abscesses inaccessible through an anterior approach [53, 56–61]. Initially reported by Butch et al. in 1986 [62], this approach requires CT guidance and patient positioning in either the prone or lateral decubitus position. The catheter should be inserted as close to the sacrum as possible at the level of the sacrospinous ligament through the piriformis muscle to avoid the sciatic nerve (situated more laterally), the gluteal vessels and the sacral plexus (Fig. 3). These authors reported a higher incidence of pain (in approximately 20% of patients) using this approach, and therefore recommended avoiding this route in children. By contrast, Gervais et al. [53] described the transgluteal approach as reasonably well tolerat-

Fig. 2a, b *Axial CT images of a fluid collection in the right abdomen*. In this case, the optimal access route for PAD is lateral trans-abdominal since the anterior abdominal approach is not recommended due to the interposed bowel loops. **a** Before treatment. **b** During treatment

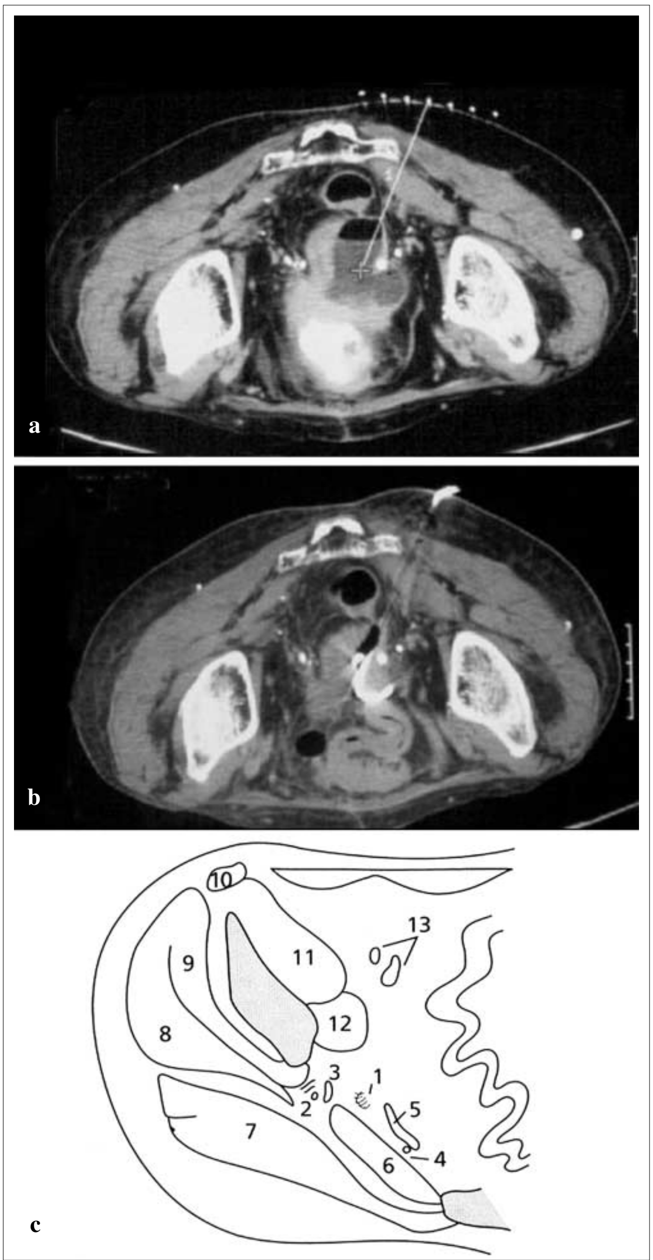

Fig. 3a-c *Transgluteal approach for PAD.* **a** Axial CT image showing the planning of the transgluteal approach to drain a collection anterior to the rectum (the patient is in prone decubitus position). **b** The catheter was then inserted through the piriformis muscle, close to the sacrum at the level of the sacrospinous ligament, to avoid puncturing the sacral plexus and the main vascular and neural structures. **c** Pelvis in axial view: *1*, sacral plexus; *2*, sciatic nerve; *3*, superior gluteal nerve and vessels; *4*, inferior gluteal artery; *5*, inferior gluteal vein and internal iliac vein; *6*, piriformis muscle; *7–9*, gluteal muscles; *10*, sartorium muscle; *11*, iliac muscle; *12*, psoas muscle; *13*, external iliac artery and vein

ed by children. After these reports, no further major studies evaluated the transgluteal approach, until 2003 when Harisinghani et al. [57] demonstrated its efficacy in a larger series (154 abscesses), reporting a success rate of 96%, a minor complication rate of 2% and no procedure-related mortality.

- *Transperineal approach* can sometimes be used for abscesses located in the low presacral or perirectal space or perineum. This procedure might be technically demanding and require a tilt of the gantry under CT guidance, or real-time monitoring of catheter angulation under US guidance [63–65]. Sperling et al. [65] reported clinical success in 90% of patients treated by transperineal US-guided approach. This approach was recommended for deep pelvic abscesses not accessible by other approaches especially in patients who have recently undergone an abdominoperineal resection for rectal carcinoma or local radiation therapy.
- *Transvaginal and transrectal drainage* [66–71] under CT or, better, US guidance allow safe access to deep-seated abscesses close to the vagina or rectum. The indications for transvaginal drainage of pelvic fluid collections include both gynecologic and non-gynecologic conditions, such as simple or complex tubo-ovarian abscesses, postoperative abscesses and diverticular abscesses. In the literature, success rates close to 100% using a US-guided transvaginal approach have been reported but all the studies enrolled small populations and lacked statistical significance [62, 72–77]. More recently, Rose et al. [78] studied a larger population (n=46) and reported that 3D reconstruction during the US-guided approach can add substantial information on structure and spatial resolution to optimize the initial drainage of complex fluid collections. In this study, PAD was curative in 77% of patients.

Procedure performance

As a general rule, diagnostic needle aspiration usually precedes catheter placement to evaluate the content of the fluid collection. PAD may be performed using three different techniques [20, 22, 40, 42, 46–50, 79–88]:

(a) The direct trocar technique is the easiest and the most common. The assembled catheter (needle-stylet + metal stiffener + plastic catheter) is inserted directly (Fig. 4).
(b) The "tandem" technique consists of needle insertion followed by insertion of the assembled catheter (needle-stylet + metal stiffener + plastic catheter), which is guided by the diagnostic needle already in place (Fig. 5).
(c) The Seldinger technique consists of insertion of a sheath-needle set (Accustick Introducer System, Boston Scientific) into the fluid collection, followed by definitive drainage.

The latter two techniques are more time-consuming and are used to drain multiloculated deep pelvic fluid collections whenever the access route is limited and there may be a risk of injury to vital structures.

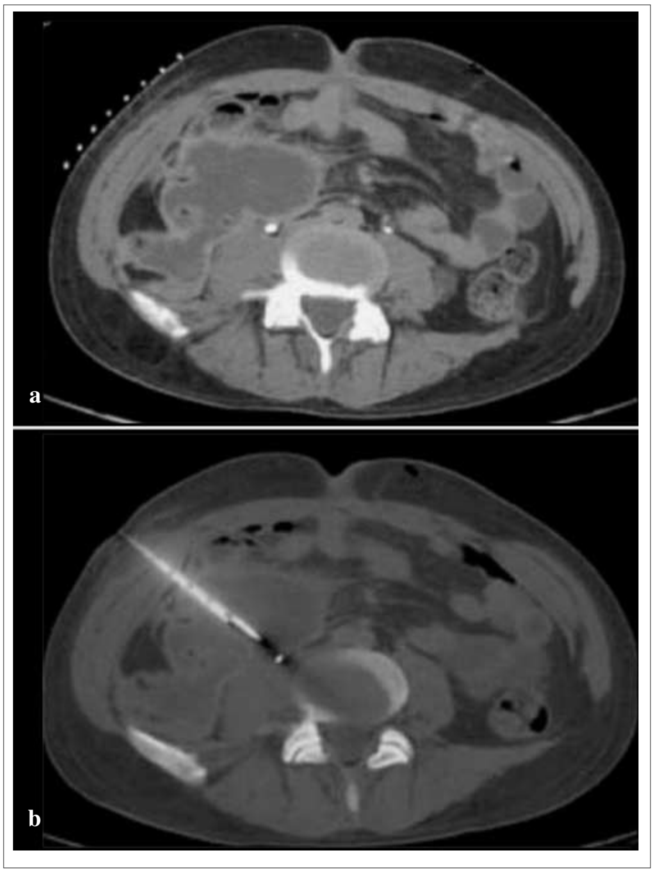

Fig. 4a, b *Direct trocar technique*. **a** Axial CT image of a deep multiloculated abscess within the bowel loops. The presence of bowel loops precluded a direct anterior approach, preferring a lateral trans-abdominal access route. The direct trocar technique was chosen to drain the collection. **b** The assembled catheter (needle-stylet + metal stiffener + plastic catheter) was inserted directly into the abscess cavity

After its placement, the catheter should be externally anchored with an adhesive-backed locking device. A bag should be attached for gravity drainage after placing a stopcock at the catheter's external end for routine irrigation. The drainage catheter's effectiveness is determined chiefly by the density of the collection: the more viscous the fluid is, the larger the catheter needed. Drainage of cysts, seromas, and noninfected abscesses may be accomplished with a 7–9 F catheter, while removal of necrotic debris requires 10–20 F catheters. Multiple catheters may be needed for larger collections.

In case of loculated collections and hematomas, therapy may be enhanced by intracavitary fibrinolytic agents such as urokinase to break loculations and lyse blood clots [81, 89].

Regarding post-procedure management, systemic antibiotic therapy should be given until signs and symptoms of infection abate. Daily irrigation of the catheter with 15–50 ml saline is recommended to maintain patency, depending on the viscosity of the fluid drained.

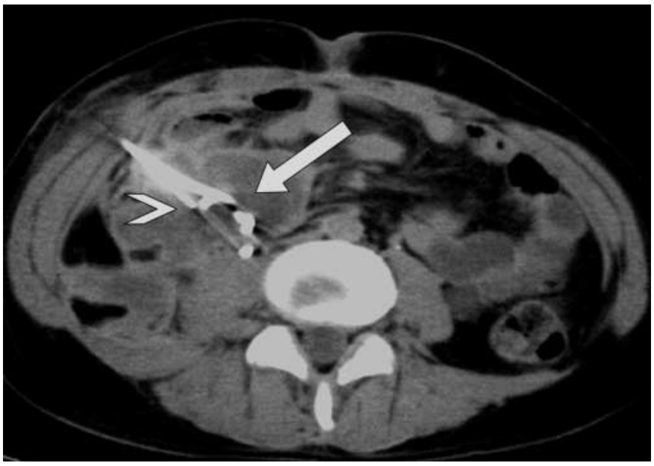

Fig. 5 Axial CT image of a deep fluid collection drained with the "tandem" technique: a 20 gauge needle was advanced into the abscess cavity (*arrowhead*) as a guide for catheter insertion (*arrow*) in tandem with the needle (alongside the diagnostic needle already in place)

Defervescence is expected in 24–48 hours and catheter output usually decreases in 2–7 days. In case of persistent fever, suggesting undrained pus, it is necessary to repeat CT: if the catheter has been dislodged, repositioning under fluoroscopy may be needed or additional catheters may be required. A sudden increase or change in fluid (from pus to bowel content) should alert to fistulous communications with the bowel.

Decisions to remove the catheter are based on clinical criteria (improvement in clinical signs, decrease in drainage to amounts less than 10 ml per 24 hours) and imaging criteria (progressive disappearance of the cavity on CT).

Outcome (success and complication rates)

PAD is a permanent curative treatment of simple abscesses in the absence of enteric communications or after closure of existing fistulas.

The success rate in abdominal abscess (i.e. resolution of the collection) is high (~90%) under favorable conditions such as: lesions situated in the periphery of the abdomen, uncomplicated access routes through the abdominal wall, homogeneous fluid collections in undivided or communicating spaces, and etiology of postoperative complications without a primary intra-abdominal disease [90, 91]. Failure of PAD is described in 8%–30% of cases and is related to the presence of loculations, phlegmon, immature abscess membrane, wide associated fistula, improper catheter position, and premature catheter removal. In the latter two circumstances, catheter repositioning or further drainage is mandatory. Predictors of unsuccessful outcome of PAD are: abscesses caused by

Fig. 6 Pre-drainage CT evaluation, with poor expected success of drainage. Multiloculated abscess caused by multiple internal fistulas, with abnormal communication with the bowel loops

internal fistulas, multiloculated and multiple abscesses (Fig. 6), pancreatic involvement by abscesses, infected clots impossible to drain, persistent abscess formation despite drainage, advanced age, high APACHE II score and malnutrition [64]. Partial success due to recurrent abscesses, related to the presence of wide fistulas which are an indication for surgical repair, has been reported in 8%–18% of cases [5, 20, 22, 40, 47, 50, 80, 92].

PAD in complicated CD has a lower success (curative) rate, ranging from 28% to 50% [16–18, 90] for spontaneous abscesses, due to the frequent concomitant wide fistulas, against 77% for postoperative abscesses [21, 40, 83]. Documentation of a fistula is a significant predictor of the need for subsequent surgery [90]. Long-term (3-week) drainage of the abscess cavity is often needed to avoid fecal fistula or recurrent abscess [90, 93]. Predictors of success in PAD in CD include the absence of fistula, first collection (vs. recurrent collection), postoperative (vs. spontaneous) abscesses, small size of the fluid collections and their location in the right lower quadrant [91], and large fistula associated with concurrent steroid therapy [19]. Nevertheless, PAD for complicated abscesses in CD is a palliative treatment, allowing a temporary improvement in general clinical conditions prior to a "cleaner" elective surgery, thereby reducing surgical morbidity, mortality and postoperative hospital stay [41, 93–95].

In a recently published series of PAD in pelvic abscess complicating CD [96], we obtained much higher success rates: a 77% primary success rate and an 84.3% secondary success rate. This was mainly due to the operators' technical experience and to the constant monitoring of drainage output in close cooperation with the surgical staff. The success rate for PAD was confirmed to be higher for postoperative (88.2%) than for spontaneous (74.2%) abscesses. Seventy-two percent of treated patients did not develop recurrent abscesses and underwent elective surgery of the diseased bowel segments up to 40 months later.

Complications of PAD for both spontaneous and postsurgical abscesses occur in 8%–10% of cases. Mortality at 30 days ranges from 1% to 6% and puncture-related mortality is around 0.7% [20, 22, 40, 46–48, 80, 97]. Major complications have been described in 5%–11% of cases and include septicemia (with associated disseminated intravascular coagulation or hypotension), small bowel fistula with colon perforation, and death (due to sepsis or hemorrhage). Minor complications, such as bacteremia, catheter back bleeding and entry-site skin infection, occur in around 3% of cases.

In conclusion, PAD is a safe and effective alternative to surgery for draining deep infected fluid collections. Meticulous technique and access planning can reduce the incidence of complications and improve the success rate of this percutaneous procedure. Close cooperation in a team composed of interventional radiologists, surgeons and physicians, selecting the appropriate indications and management throughout treatment, is mandatory for a successful application of these well tolerated interventional procedures.

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