

Determinants for Successful Percutaneous Image-Guided Drainage of Intra-abdominal Abscess

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Hypothesis: Characteristics of intra-abdominal abscess can be used to predict successful outcome for percutaneous catheter drainage (PCD).

Methods: We performed a multicenter prospective study of patients who had intra-abdominal infections treated with PCD and intravenous antibiotics. Multivariate regression analysis determined predictors of successful outcome.

Results: The study included 96 patients (59% men; mean±SD age, 48±17 years; mean±SD Acute Physiology and Chronic Health Evaluation II score, 7.4±4.9). Postoperative abscess was present in 53% of patients. Isolated microorganisms included *Bacteroides* species (17%), *Escherichia coli* (17%), *Streptococcus* species (14%), *Enterococcus* species (10%), and fungi (11%). Single abscesses were present in 83% of patients. Computed tomographic guidance was used for drainage in 80% of patients, and ultrasound was used in 20%. The duration of abscess drainage was less than 14 days in 64%. Com-

plete resolution of the infection with a single treatment of PCD was achieved in 67 patients (70%), and with a second attempt in 12 (12%). Thirty-three patients (34%) had PCD for the resolution of intra-abdominal sepsis prior to an elective, definitive procedure. Open drainage as a result of PCD failure was required in 15 (16%) and was more likely in patients with yeast ($P<.001$) or a pancreatic process ($P=.02$). Postoperative abscess ($P=.04$) was an independent predictor of successful outcome.

Conclusions: Percutaneous catheter drainage of intra-abdominal infections was effective with a single treatment in 70% of patients and increased to 82% with a second attempt. A successful outcome is most likely with abscesses that are postoperative, not pancreatic, and not infected with yeast. Percutaneous catheter drainage is now a commonly used staging method for the resolution of intra-abdominal sepsis prior to corrective operation.

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IMAGE-GUIDED percutaneous catheter drainage (PCD) has been shown to be effective therapy in carefully selected patients who have intra-abdominal abscesses.¹ Hemming et al² demonstrated that patients who underwent PCD of intra-abdominal abscesses had the same length of stay, morbidity rate, and mortality rate as matched patients stratified for site and severity who had open operative drainage. In this article, we aim to refine the judgment leading to a recommendation for PCD by determining the characteristics of intra-abdominal abscess that result in resolution of the infection without laparotomy.

RESULTS

PATIENT DEMOGRAPHICS

During a 3-year period, 529 patients with signs and symptoms of severe intra-

abdominal infection were enrolled in our study. Of these patients, 96 were treated with PCD and are the basis for this article. The mean±SD age was 48±17 years; 59% were men. Patients had an average of 3 preexisting medical illnesses, with a mean±SD APACHE II score of 7.4±4.9 (range, 0-21). The mean±SD follow-up time was 40.3±20.0 days (range, 8-130 days). There were no deaths during the study period in patients who underwent PCD.

INTRA-ABDOMINAL ABSCESSSES

A total of 137 abscesses were diagnosed in 96 patients. Drainage took place at a mean±SD time of 5.5±10 days after admission. The imaging modality used for diagnosis was CT in 85 patients (89%) and ultrasound in 11 patients (11%). Fifty-one abscesses (53%) were postoperative and were diagnosed at a mean±SD time

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PATIENTS AND METHODS

Between September 1994 and February 1997, adult patients with intra-abdominal infection were prospectively enrolled in a multicenter trial. The institutional review board of each site approved the protocol. Patients were eligible for inclusion if they were 18 years or older, showed signs and symptoms of intra-abdominal infection, and required operative drainage or PCD. Patients were initially treated with PCD or open surgical drainage according to the judgment of the surgeon and interventional radiologist. Abscess collections were of a size to be clearly identified on computed tomography (CT), to be accessible by percutaneous puncture, and to contain enough fluid for microbiological testing. All abscesses were greater than 2 cm in diameter. This article examines the outcome of patients who were treated with PCD.

Following drainage, the fluid underwent a gram stain and culture. Standard treatment with intravenous antibiotics was then carried out according to the direction of the attending physician. Nurse study monitors prospectively recorded patient characteristics including sex, age, Acute Physiology and Chronic Health Evaluation (APACHE) II scores, and preexisting illnesses. Intra-abdominal infections were classified by origin and location on imaging studies. All results of microbiological studies and cultures were recorded. Follow-up visits and patient outcomes were monitored.

Successful PCD was defined as 1 or more PCD procedures that resulted in the complete resolution of both symptoms and fluid collections identified on imaging studies without the need for open operative drainage to resolve the acute septic process. Failure of PCD was defined as the need to convert to operative treatment or open drainage prior to complete resolution of the intra-abdominal infection. Staged procedures were defined as the use of PCD to completely resolve an acute septic process prior to a planned elective surgical procedure.

Multivariate regression analysis was used to identify predictors of successful outcome following PCD. Variables entered into the analysis included age, sex, APACHE II score, postoperative abscess, single abscess on an initial CT scan, the presence of yeast on a gram stain or culture, the number of organisms identified, 2 or fewer attempts at drainage, and an infection of pancreatic origin. The *t* test, χ^2 analysis, and analysis of variance were used to compare groups.

of 22 ± 29 days after operation. Eighty patients (83%) had a single abscess on the initial CT scan, whereas 16 patients (17%) had 2 or more abscesses. Seven patients (7%) developed additional abscesses after the initial CT scan.

The predominant source of intra-abdominal infection and the locations of the abscesses on imaging studies are summarized in **Table 1** and **Table 2**.

Table 1. Origin of Intra-abdominal Abscesses

Origin	No. (%)
Colon and rectum	27 (28)
Liver and biliary tree	20 (21)
Appendix	19 (20)
Pancreas	12 (13)
Small bowel	8 (8)
Stomach and duodenum	6 (6)
Renal	1 (1)
Unknown	3 (3)

Table 2. Location of Abscess on Diagnostic Imaging Study

Location	No. (%)
Right lower quadrant/flank/gutter	24 (25)
Right subphrenic/subhepatic	22 (22)
Left lower quadrant/flank/gutter	21 (22)
Pelvis/perirectal	16 (17)
Lesser sac	16 (17)
Left subphrenic	4 (4)
Retroperitoneal (perinephric/psoas)	4 (4)
Biliary tree	3 (3)
Other intraperitoneal	5 (5)

MICROBIOLOGICAL CHARACTERISTICS

The intra-abdominal fluid of all patients showed bacterial abnormalities. A total of 290 bacterial isolates were identified and included *Bacteroides* species (17%; *n*=50), *Escherichia coli* (17%; *n*=49), *Streptococcus* species (14%; *n*=41), *Enterococcus* species (10%; *n*=30), and *Klebsiella* species (6%; *n*=18) (**Table 3**). Sixty-four patients (67%) had polymicrobial abscesses; the overall mean \pm SD number of isolates was 3.0 ± 2.5 organisms per patient.

Yeast was isolated from abscesses in 11 patients (11%). These patients were treated with antimicrobial drugs for a mean \pm SD duration of 9.5 ± 4.4 days prior to the identification of yeast. The source of infection for patients with yeast was the colon and rectum (55%; *n*=6), stomach and duodenum (18%; *n*=2), liver or biliary tract (18%; *n*=2), and pancreas (9%; *n*=1).

Postoperative abscesses yielded fewer organisms than those that were not postoperative (2.5 organisms vs 3.6 organisms; *P*=.02) and were more likely to contain *Enterococcus* species (37% vs 13%; *P*=.007). Primary (non-postoperative abscesses) were more likely to contain *Escherichia coli* (57% vs 27%; *P*=.002), *Streptococcus* species (46% vs 13%; *P*<.001), and *Bacteroides* species (44% vs 24%; *P*=.03).

PCD OF ABSCESSSES

Percutaneous drains were placed using CT guidance in 80% of patients (*n*=77), ultrasound in 18% (*n*=17), and fluoroscopy in 2% (*n*=2). The duration of abscess drainage was less than 14 days in 64% of patients. The average duration of drainage was 14.1 days.

Percutaneous catheter drainage resulted in a success rate of 70% (*n*=67) with a single attempt, increased to 82%

Table 3. Bacterial and Fungal Isolates

Organism	No. (%)
<i>Bacteroides</i> species	50 (17)
<i>Escherichia coli</i>	49 (17)
<i>Streptococcus</i> species	41 (14)
<i>Enterococcus</i> species	30 (10)
<i>Klebsiella</i> species	18 (6)
<i>Clostridium</i> species	14 (5)
<i>Peptostreptococcus</i> species	11 (4)
<i>Enterobacter</i> species	11 (4)
<i>Staphylococcus</i> species	11 (4)
Yeast	11 (4)
Other	55 (19)

Table 4. Cumulative Success Rates for Multiple Attempts With Percutaneous Catheter Drainage

No. of Attempts	No. Successful	Cumulative Success Rate, %
1	67	70
2	12	82
3	1	83
4	1	84
5	0	84

(n = 12) with a second attempt, and reached 84% (n = 2) with additional attempts (**Table 4**). Overall, 23% of patients required repeated drainage. Patients who required more than 2 drainage attempts had a greater number of abscesses (2.3 vs 1.4; $P = .04$), a higher incidence of complications (75% of patients vs 28% of patients; $P = .05$), and a significantly lower success rate (50% vs 86%; $P = .05$).

Percutaneous catheter drainage was successful in 90% of postoperative abscesses (46/51) and 78% (35/45) of abscesses that were not postoperative ($P = .09$). The success rate also varied by origin of intra-abdominal infection: appendix, 95% (18/19); liver or biliary tract, 85% (17/20); colon and rectum, 78% (21/27); pancreas, 58% (7/12); or other, 100% (18/18) (analysis of variance; $P = .04$). Of the infections that were of pancreatic origin, the success rate was 75% (6/8) for postoperative abscesses, 0% (0/1) for primary pancreatic abscesses, and 33% (1/3) for pseudocysts.

The overall success rate for nonstaged procedures was 89% (55/62). Percutaneous catheter drainage completely resolved intra-abdominal infection prior to an elective, definitive operation in 26 (76%) of 34 patients (**Table 5**). Success rate varied according to the disease process: interval appendectomy, 94% (15/16); staged diverticulitis, 62% (8/13); and other (pancreas, biliary tract, or small bowel), 60% (3/5). Of the patients who underwent successful procedures in anticipation of a subsequent elective, definitive operation, only 4 (16%) underwent elective operation during the same admission; 21 (84%) were scheduled for operation at a later date.

Failures occurred in 15 (16%) of the 96 patients who had PCD. Eight (53%) of these procedures failed at an attempt to resolve infection prior to a definitive procedure and are detailed previously. Of the remaining 7 at-

Table 5. Outcome of Staged Surgical Procedures Using Percutaneous Catheter Drainage

Origin	No. of Successes	No. of Failures	Success Rate, %
Appendicitis	15	1	94
Diverticulitis	8	5	62
Other	3	2	60
Overall Success	26	8	76

Table 6. Adverse Events Following Percutaneous Catheter Drainage

Adverse Event	No. of Patients
Drain-related	19
Falling out	8
Manipulation or reposition required	7
Damaged	2
Obstructed	2
Rehospitalization	7
Fistula formation	4
Bleeding	4
Cellulitis	3
Inability to place drain	2
Total	39

tempts, 5 were for pancreatic infections, 1 was for obstructive ascending cholangitis, and 1 was for an anastomotic leak following a low anterior resection that eventually required open drainage and a diverting colostomy to treat continued pelvic sepsis.

ADVERSE EVENTS

A total of 39 adverse events occurred in 30 patients. Drain-related complications were the most common (51%; n = 19) and included the drain falling out early (n = 8), becoming damaged (n = 2), becoming obstructed (n = 2), and requiring manipulation or repositioning (n = 7). Other adverse events included cellulitis surrounding the drain entry (n = 3), fistula formation (n = 4), bleeding (n = 4), rehospitalization (n = 7), and the inability to place a drain (n = 2) (**Table 6**). Of the 4 fistulas identified, 3 were successfully treated with PCD alone; 1 required open drainage and diversion.

PREDICTORS OF OUTCOME

To determine predictors of outcome with PCD, multivariate regression analysis was performed. Variables included age, sex, APACHE II score, postoperative abscess, single abscess on an initial CT scan, the presence of yeast on a gram stain or culture, the number of organisms identified, 2 or fewer attempts at drainage, and pancreatic origin. Of these, postoperative abscess was the only independent predictor of successful outcome (odds ratio [OR] = 1.15; 95% confidence interval [CI], 1.00-1.31; $P = .04$). Negative predictors of successful outcome included the presence of yeast (OR = 0.63; 95% CI, 0.51-0.78; $P < .001$) and pancreatic origin (OR = 0.78; 95% CI, 0.63-0.96; $P = .002$) (**Table 7**).

Table 7. Predictors of Outcome for Percutaneous Catheter Drainage

Variable	Odds Ratio*	Confidence Interval	P Value
Postoperative abscess	1.15	1.001-1.31	.04
Yeast	0.65	0.52-0.81	<.001
Pancreatic origin	0.72	0.58-0.80	.02

*Odds ratios were determined using exponent b.

COMMENT

One of the most significant advances in the treatment of intra-abdominal infection during the past 2 decades has been the introduction of image-guided therapy with PCD. The development of improved imaging modalities, together with broad-spectrum antibiotics and soft drainage catheters, has changed the treatment of infections that previously required an urgent operation. Disease processes that have traditionally been treated with open surgical drainage and debridement can now be resolved with PCD and antibiotics. In selected cases, this will allow for better preparation of the patient for a later elective and definitive operation.

Image-guided PCD began in the late 1970s.^{3,4} In 1981, Gerzof et al¹ reported a success rate of 86% in 67 patients who underwent PCD of intra-abdominal abscess. Within the next several years, additional reports demonstrated excellent results with success rates ranging from 60% to 80%.⁵⁻⁸ The criteria for drainage soon expanded to include more complex infections and up to 3 abscess sites.^{9,10} Retrospective studies demonstrated equivalence in outcome when PCD was compared with surgical drainage in patients matched for age, cause of disease, and severity of illness.^{2,7,11-15} Percutaneous catheter drainage is currently the accepted treatment for several types of intra-abdominal infections, including discrete postoperative abscesses and accessible diverticular abscesses.^{16,17} Patient selection, however, is of critical importance. Improper patient selection with incomplete drainage has been shown to cause a significant increase in morbidity and mortality rates.¹⁸⁻²⁰

This article is intended to refine the judgment of physicians who treat patients with intra-abdominal infection using PCD. We analyzed patients who underwent PCD as the initial therapy for severe intra-abdominal infection to determine the characteristics favoring successful outcome. We also sought to determine if repeated drainage procedures were useful. The overall mortality rate of 0% in our study compares favorably with the literature^{2,7,11-20} and suggests that the selection for PCD and subsequent conversion to open drainage was appropriate in the study group.

Our analysis found that 70% of patients with intra-abdominal abscess selected for image-guided PCD could be treated with a single percutaneous procedure and a full course of antibiotics. A second PCD attempt resulted in a successful outcome for an additional 12% of patients. Laparotomy was required in the 16% of patients in whom PCD failed, and was more likely in pa-

tients with yeast in the abscess, with a pancreatic infection, and who required more than 2 drainage attempts.

Our study also demonstrates that PCD has had a major effect on resolving intra-abdominal sepsis, thus allowing a definitive operation to be planned on an elective basis after hospital discharge and with better preparation of the patient (eg, bowel preparation). This approach is most successful for colorectal and appendiceal abscesses. Previous retrospective reviews have demonstrated that diverticular abscesses may be drained percutaneously and that colostomy can be avoided by resolving sepsis so that bowel preparation and 1-stage resection are safe.²¹⁻²⁷ We found that in 35% of our patients, PCD was used prior to a planned procedure, with an overall success rate of 76%. Interval appendectomy and sigmoid resection for diverticulitis were the most common elective procedures, with success rates of 94% and 62%, respectively, for resolving intra-abdominal sepsis and completing the planned resection.

The poor outcome of PCD associated with the presence of yeast and a pancreatic process is consistent with that in the previously published literature.²⁸⁻³⁴ The presence of yeast suggests prolonged exposure to broad-spectrum antimicrobial drugs, immunosuppression, diabetes, or perhaps a more refractory process; however, we had only 11 patients in this group. Overall, the average duration of antimicrobial exposure prior to the identification of yeast was 9.5 days. Pancreatic abscesses have also been shown to be refractory to PCD when compared with intra-abdominal abscesses from other sources. The subsets of patients with pancreatic infection¹² or yeast-containing abscesses¹¹ were too small to allow further analysis of risk factors predicting success. Success rates have ranged from 30% to 80% depending on patient selection. We found an overall success rate of 58%. This rate was better for patients with postoperative peripancreatic abscesses (66%) but poorer for those with primary pancreatic abscesses and infected pseudocysts (33%).

The bacterial isolates identified from the PCD confirm the predominance of polymicrobial microorganisms in intra-abdominal infections. Adjunctive antimicrobial therapy must be directed at enteric, gram-negative rods, gram-positive cocci, and anaerobes. Anaerobes accounted for more than 20% of all isolates. The increased incidence of *Enterococcus* species in postoperative abscesses was likely due to selection by perioperative antimicrobial drugs, which are frequently cephalosporins. Antimicrobial therapy for postoperative abscess should have a broad spectrum to ensure coverage of these organisms.

In conclusion, PCD with adjunctive intravenous antibiotics is an effective therapy for many patients who have intra-abdominal abscesses. It is especially useful in the treatment of diverticular, appendiceal, and hepatobiliary abscesses. Percutaneous drainage is successful on the first attempt in 70% of patients who are judged by the surgeon and radiologist to be suitable candidates. A second attempt at PCD extends the resolution of infection to 82%, but further drainage attempts are unlikely to be successful. Strong consideration should be given to open operative drainage rather than PCD if more than 2 attempts are required. An emerging and prominent role for

PCD is the resolution of acute septic events, thus allowing a later elective, definitive procedure. With careful selection and appropriate antimicrobial therapy, PCD can effectively resolve infection in up to 80% of patients who have intra-abdominal abscesses.

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