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# Differences in Morbidity and Mortality with Percutaneous versus Open Surgical Drainage of Postoperative Intra-abdominal Infections: A Review of 686 Cases

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## Abstract

Intra-abdominal infections following surgical procedures result from organ-space surgical site infections, visceral perforations, or anastomotic leaks. We hypothesized that open surgical drainage is associated with increased patient morbidity and mortality compared with percutaneous drainage. A single-institution, prospectively collected database over a 13-year period revealed 2776 intra-abdominal infections, 686 of which required an intervention after the index operation. Percutaneous procedures (simple aspiration or catheter placement) were compared with all other open procedures by univariate and multivariate analyses. Analysis revealed 327 infections in 240 patients undergoing open surgical drainage and 359 infections in 260 patients receiving percutaneous drainage. Those undergoing open drainage had significantly higher Acute Physiology Score (APS) and Acute Physiology and Chronic Health Evaluation (APACHE) II scores and were more likely to be immunosuppressed, require intensive care unit treatment, and have longer hospital stays. Mortality was higher in the open group: 14.6 *versus* 4.2 per cent ($P$ = 0.0001). Variables independently associated with death by multivariate analysis were APACHE II, dialysis, intensive care unit (ICU) care, age, immunosuppression, and drainage method. Open intervention for postsurgical intra-abdominal infections is associated with increased mortality compared with percutaneous drainage even after controlling for severity of illness by multivariate analysis. Although some patients are not candidates for percutaneous drainage, it should be considered the preferential treatment in eligible patients.

Criteria for control or treatment of intra-abdominal infections include early diagnosis, appropriate antibiotics, source control, and supportive care.[1] For primary (spontaneous) peritonitis, antibiotics alone may suffice. For secondary peritonitis in which the infection is caused by contamination from a perforated viscus, source control can be obtained by a variety of methods, including drainage, repair, resection, or diversion. Tertiary peritonitis is a more vague entity that may also be effectively treated by these methods but that needs assessment and intervention individualized to the situation.

Current guidelines from the Surgical Infection Society and the Infectious Diseases Society of America for treatment of intra-abdominal infections include obtaining appropriate source control.[2] For diffuse peritonitis, urgent surgical intervention is recommended, whereas for localized fluid collections that are accessible, percutaneous drainage (PD) is preferred over open surgical drainage (SD). Several studies comparing the effectiveness of PD *versus* SD

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for intra-abdominal infections have shown equivalence between these procedures. In more recent years, there have been several studies that describe the safety and efficacy of PD, yet most of the comparison studies were performed in the mid-1980s with the most recent study in 1998.

Most of these studies do not specifically address patients with an infection after a recent surgical procedure, although it is the most common reason for reoperation.[3] In this setting, the infection can arise from an organ-space surgical site infection, a visceral perforation, or an anastomotic leak. Mortality from intra-abdominal sepsis can be as high as 30 to 35 per cent,[4–6] with mortality in patients requiring a second operation reaching 50 per cent[5] and in those with an undrained abscess exceeding 90 per cent,[7–9] often as result of multiple organ failure.[5]

In recent years, both PD techniques and critical care for the postoperative patient have advanced significantly. Concerns regarding a patient's ability to tolerate the physiological stress of a second major operative procedure weigh against the need to provide definitive source control and may influence the decision regarding method of control selected. We evaluated a prospectively collected database for postoperative intra-abdominal infections and hypothesized that percutaneous drainage would result in not just equivalent, but superior outcomes compared with open surgical drainage.

## Methods

Over a 13-year period, records for all patients on the general surgery units at our hospital were evaluated for infections using three times weekly chart review and a prospective database was maintained that included complete demographic data, comorbidities, Acute Physiology Scores (APS), and Acute Physiology and Chronic Health Evaluation II (APACHE II) scores[10], and details of the course of infection such as maximum temperature, maximum white blood cell (WBC) count, microbiology, antibiotics administered, procedures performed, and patient outcomes. Because of the nature of the data collection and the removal of patient identifiers (anonymity) before final analysis, this database was granted a waiver of consent by the University of Virginia Institutional Review Board.

The database was reviewed for all cases that were considered postoperative intra-abdominal infections, defined as an intra-abdominal infection that followed a primary procedure and that required a second intervention for treatment of that infection. Infections that met the Centers for Disease Control and Prevention definition of intra-abdominal infection (as a result of loss of integrity of an intra-abdominal organ) or organ-space surgical site infection (postoperative intra-abdominal infection in the setting of an intact gastrointestinal tract) were included. Episodes of primary/spontaneous peritonitis or peritoneal dialysis catheter-related infection were excluded. Secondary procedures to treat intra-abdominal infections were classified as either percutaneous drainage (including both simple aspiration and percutaneous drain placement) or as open surgical drainage (including all other procedures). Of note, there were no solely laparoscopic procedures performed for treatment of a postoperative intra-abdominal infection in the current data set.

Data were evaluated by type of drainage procedure patients received. Univariate analyses of patient demographics between treatment groups and between groups relative to mortality were performed using Student *t* test or Mann-Whitney *U* test for continuous variables and chi-square analysis for categorical variables. Mortality was assessed both per episode of infection and per individual patient. For the "per-patient" calculation, if more than one infection was recorded during a given hospital admission, that patient was counted only once for that admission. If a subsequent admission occurred more than 30 days from the first operation during which the patient developed a new postoperative infection, the clinical record was reviewed to determine whether the second episode was a residual infection. If it was not, it was counted as a separate patient event. All other calculations were assessed per individual episode of infection. For the purpose of data analysis, "immunosuppression" included transplant patients and patients on either chronic steroids or other form of iatrogenic immunosuppression, most commonly for chronic obstructive pulmonary disease, inflammatory bowel disease (IBD), or rheumatoid arthritis, or acute high-dose steroids at the time of diagnosis of infection. Successful drainage was defined as survival to hospital discharge without need for a subsequent procedure to treat the intra-abdominal infection. Multivariate logistic regression analysis of factors associated with mortality was performed to determine independent predictors of mortality, including type of procedure. Statistics were performed using SAS (Version 9.1.3 for Windows; SAS Institute, Cary, NC).

## Results

Review of our database revealed 2776 intra-abdominal infections. Of these, 686 involved a postoperative intra-abdominal infection requiring a second intervention for treatment of that infection. These included 327 infections in 240 patients who underwent SD and 359 infections in 260 patients who received PD.

By drainage procedure, the patients in each group were similar in terms of age, gender, body mass index, history of diabetes, dialysis dependence, IBD, maximum temperature, and WBC count (Table 1). Those undergoing SD had an average APACHE II score of 15.3 ± 0.42 compared with 11.1 ± 0.33 in the PD group, and an average APS of 11.1 ± 0.38 compared with 7.1 ± 0.27 ($P < 0.0001$). In addition, patients undergoing SD were more often immunosuppressed, (30.9% SD *vs* 18.9% PD, $P = 0.0003$) and were more likely to require treatment in the intensive care unit (ICU) during the course of their hospitalization (55.0 *vs* 22.0%, $P < 0.0001$) compared with patients who received PD. Patients who received SD had an average hospital stay of 28.1 ± 1.62 days from the time of intervention to hospital discharge compared with 13.5 ± 0.78 days in the PD group ($P < 0.0001$). Finally, overall success was 62 per cent for SD and 69 per cent for PD ($P = 0.06$).

Mortality differed significantly between groups, with a higher mortality seen in patients who received SD when analyzed by episode of infection (18.7 *vs* 6.7%, $P < 0.0001$) or by individual patient (14.6 *vs* 4.2%, $P = 0.0001$). When only patients who died were analyzed by type of drainage procedure (Table 2), significant differences were seen in WBC, history of diabetes, and immunosuppression.

Multivariate analysis demonstrated an increased risk of death in SD compared with PD (OR, 2.038; 95% CI, 1.133 to 3.668; $P = 0.0175$). Other variables that were independent predictors of death by multivariate analysis were APACHE II, dialysis, ICU care, age, and immunosuppression (Table 3).

Primary procedures most commonly involved the colon (160; 81 SD, 79 PD), the liver (108; 58 SD, 50 PD), the stomach (87; 69 SD, 18 PD), the small bowel (79; 35 SD, 44 PD), or a primary abscess (69; 27 SD, 42 PD). The most commonly isolated pathogens included *Escherichia coli* (85), *Enterococcus faecium* (80, including 54 vancomycin-resistant specimens), *Enterococcus faecalis* (79), *Staphylococcus aureus* (44, including 26 methicillin-resistant *S. aureus*), streptococcal species (44), and *Klebsiella pneumoniae* (38). There were 29 cases of nonspeciated Gram-positive cocci and 27 cases of nonspeciated Gram-negative rods as well.

## Discussion

The use of radiologic guidance techniques for the diagnosis and aspiration of intra-abdominal fluid collections was described as early as 1977.[11–13] In a 1981 review, Gerzof described radiologic placement of drainage catheters in 67 patients with intra-abdominal abscesses with satisfactory drainage of 86 per cent.[14] Of the six deaths related to sepsis in this series, three were related to inadequate drainage and ongoing sepsis. However, from these early reports, PD was established as an effective method for treatment of intra-abdominal abscesses when an accessible route was available.

Since then, several studies have compared this method using either ultrasonographic or CT guidance with open surgical drainage of intra-abdominal abscesses (Table 4). These retrospective institutional series included both postoperative infections and spontaneous primary or secondary peritonitis. Inclusion criteria differed between studies with pancreatic or pelvic abscesses excluded in some. Definitions of success also varied, including resolution with a single intervention, avoidance of a surgical procedure, or survival. Reported complication rates ranged from 4 to 50 per cent for PD and 16 to 47 per cent for SD, and mortality rates from 0 to 29 per cent for PD and 0 to 28 per cent for SD. Several authors commented on the successful drainage of infections associated with enteric fistulae, which averaged 83 per cent for PD and 72 per cent for SD.

The conclusions drawn from these studies were inconsistent, with early reports favoring PD when technically feasible[15–18] and more recent studies only demonstrating equivalence between techniques.[19–22] Still others proffered individual patient evaluation and assessment of institutional experience with PD before determining a treatment plan.[23–26]

Studies that evaluated APS[19, 22] or APACHE II scores[18, 20, 21] found no significant difference between patients in each treatment group, although the severity of illness was often significantly higher in patients who failed treatment, had complications, or died regardless of drainage method used, suggesting that overall severity of illness is more influential on patient outcomes than the method of drainage itself.[19–21] Other indicators for failure or mortality included increased age[21] and complex abscesses.[18, 27] Of note, successful treatment of collections related to enteric communication was achieved by both techniques.[15, 20, 21, 24, 28]

The risks and benefits of relaparotomy in the setting of intra-abdominal infections have been well described in the literature evaluating the optimum timing for such intervention.[1, 29, 30] Early reintervention allows for prompt detection of infectious foci, minimal postoperative adhesions, and early source control. With a negative relaparotomy rate of nearly 30 per cent in on-demand procedures,[1, 29, 31] risks include exposure to potentially unnecessary surgery and anesthesia, increased adhesions, higher costs, and exaggerated physiological response, which may predispose patients to developing multiorgan failure.[1, 32]

On the other hand, if an abscess can be detected, accessed, and undergo successful percutaneous catheter placement, many of these concerns are avoided. Success of PD depends on abscess size and location and source of infection.[28] Failure of PD is often the result of increased complexity such as extensive anastomotic leaks, multiple abscesses, nondrainable necrotic material, or extended peritonitis; if such failures are unrecognized, mortality increases substantially.[27]

Advantages of our study include its large size, use of a severity of illness scoring system, and multivariate analysis to detect independent predictors of mortality. Our study does have some limitations, however. First, it is confined to a single institution, although our data comprise the largest evaluation of postoperative infection to date. Second, the assessment of each patient was performed by the surgical team and the subsequent decision regarding method of drainage was neither randomized nor always delineated in clinical documentation. Third, our data included minimal use of laparoscopy as a treatment alternative. Finally, our use of mortality is a crude outcome, as patients may have died as a result of events unrelated to their intra-abdominal infection or relevant treatment. Nonetheless, we believe our results demonstrate the benefits of approaching such lesions by a percutaneous route when possible.

## Conclusion

Compared with previous studies that showed equal outcomes with SD *versus* PD after accounting for severity of illness,[19–21] we demonstrate that even after adjusting for severity of illness and other variables independently associated with death, PD is associated with higher patient survival than SD. Specific factors to consider before choosing an approach include the possibility that a major anatomic defect is the underlying cause (such as an early and complete anastomotic dehiscence), the potential for spreading contamination within the abdomen during an open procedure, and the patient’s ability to tolerate the physiological insult associated with an operation. In addition, PD may be a very reasonable temporizing measure until the patient has been stabilized and can tolerate an open procedure or until the acute inflammation has resolved enough to allow for a single-stage operation. Like other studies have demonstrated, continuity of the abscess with the bowel lumen does not mandate SD nor is it a marker for decreased success with PD. Although clinical and surgical judgment must be weighed carefully in determining the best approach for each patient, if a patient is a candidate for percutaneous drainage, we would favor that approach.

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## Table 1

Demographic Information by Type of Drainage Procedure Performed*

| | PD (n = 359) | SD (n = 327) | *P* |
|---|---|---|---|
| Age | 52.9 ± 0.87 | 52.3 ± 0.84 | 0.60† |
| APACHE II | 11.1 ± 0.33 | 15.3 ± 0.42 | <0.0001† |
| Acute Physiology Score | 7.1 ± 0.27 | 11.1 ± 0.38 | <0.0001† |
| Body mass index | 28.9 ± 0.66 | 29.8 ± 0.88 | 0.42† |
| Maximum temperature | 37.8 ± 0.05 | 37.9 ± 0.06 | 0.28† |
| White blood cell count | 17.1 ± 0.43 | 16.5 ± 0.53 | 0.37† |
| Days to discharge | 7 (0–14) | 17 (3–31) | <0.0001‡ |
| Gender | 204 male/155 female | 174 male/153 female | 0.34§ |
| Diabetes mellitus | 75 (27.1%) | 69 (24.3%) | 0.42§ |
| Hemodialysis | 17 (4.7%) | 27 (8.3%) | 0.06§ |
| Inflammatory bowel disease | 25 (7.0%) | 19 (5.8%) | 0.54§ |
| Immunosuppression | 68 (18.9%) | 101 (30.9%) | 0.0003§ |
| Intensive care unit care | 79 (22.0%) | 180 (55.0%) | <0.0001§ |
| Mortality per infection | 24 (6.7%) | 61 (18.7%) | <0.0001§ |
| Mortality per patient | 11/260 (4.2%) | 35/240 (14.6%) | 0.0001§ |

*Results are presented as mean ± SE, median (25 to 75%), or no. (%), and analyses are

†independent *t* test,

‡Mann-Whitney-*U* test, or

§chi-square test.

PD, percutaneous drainage; SD, surgical drainage; APACHE, Acute Physiology and Chronic Health Evaluation.

## Table 2

Demographic Differences by Type of Drainage Procedure among Those Patients Who Died*

| | PD (n = 24) | SD (n = 61) | *P* |
|---|---|---|---|
| Age | 58.3 ± 2.91 | 54.5 ± 1.80 | 0.28† |
| APACHE II | 19.6 ± 1.73 | 18.7 ± 1.10 | 0.67† |
| Acute Physiology Score | 13.9 ± 1.50 | 13.0 ± 1.14 | 0.66† |
| Body mass index | 26.8 ± 2.80 | 28.1 ± 1.80 | 0.69† |
| Maximum temperature | 37.4 ± 0.25 | 37.6 ± 0.14 | 0.39† |
| White blood cell count | 26.9 ± 2.93 | 18.1 ± 1.65 | 0.007† |
| Gender | 17 male/7 female | 36 male/25 female | 0.31§ |
| Diabetes mellitus | 9 (37.5%) | 10 (16.7%) | 0.04§ |
| Hemodialysis | 10 (41.7%) | 14 (23.0%) | 0.08§ |
| Immunosuppression | 2 (8.3%) | 35 (57.4%) | <0.0001§ |
| Intensive care unit care | 20 (83.3%) | 44 (72.1%) | 0.28§ |
| Days to discharge | 18 (9.5–27.5) | 27 (3–51) | 0.15‡ |

*Results are presented as mean ± SE, median (25 to 75%), or no. (%), and analyses are

†independent *t* test,

‡Mann-Whitney-*U* test, or

§chi-square test.

PD, percutaneous drainage; SD, surgical drainage; APACHE, Acute Physiology and Chronic Health Evaluation.

## Table 3

Odds Ratios of Independent Predictors of Mortality and Their Respective 95% Confidence Intervals

| | Odds Ratio | 95% Confidence Interval | Wald Chi-square | *P* |
|---|---|---|---|---|
| Open vs percutaneous | 2.038 | 1.133–3.668 | 5.65 | 0.0175 |
| Hemodialysis | 5.215 | 2.455–11.076 | 18.47 | <0.0001 |
| Intensive care unit care | 2.856 | 1.535–5.312 | 10.98 | 0.0009 |
| Immunosuppression | 1.779 | 1.002–3.157 | 3.87 | 0.05 |
| APACHE II | 1.043 | 1.004–1.084 | 4.61 | 0.0317 |
| White blood cell count | 1.026 | 0.999–1.053 | 3.64 | 0.06 |
| Age | 1.021 | 1.002–1.040 | 4.89 | 0.027 |

APACHE, Acute Physiology and Chronic Health Evaluation.

## Table 4

Summary of Previous Studies Comparing Percutaneous and Open Surgical Drainage Procedures for Intra-abdominal Infections

| | PD (%postoperative) | SD (%postoperative) | Success (%) | | Morbidity (%) | | Mortality (%) | |
|---|---|---|---|---|---|---|---|---|
| | | | PD | SD | PD | SD | PD | SD |
| Johnson (1981) with fistulae | 27 (52) | 43 (60) | 89 | 70 | 4 | 16 | 11 | 21 |
| | 5 | 0 | 100 | — | | | | |
| Halasz (1983) with fistulae | 11 (64) | 19 (84) | — | — | 27† | 21† | 9 | 16‡ |
| | 3 | 2 | | | | | | |
| Aeder (1983) with fistulae | 11 (64) | 31 (35) | 69 | 71 | 36† | 47 | 27‡ | 23‡ |
| | 3 | 4 | 66 | — | | | | |
| Brolin (1984) with fistulae | 24 (71) | 24 (67) | 92 | 88 | 13† | 21† | 0 | 13 |
| | 3 | 2 | | | | | | |
| Glass (1984) with fistulae | 15 (–) | 41 (–) | 47 | 88 | 6 | 23 | — | — |
| | — | — | | | | | | |
| Lurie (1987) with fistulae | 29 (–) | 60 (–) | 80 | 81 | — | — | 17 | 17 |
| | — | — | | | | | | |
| Olak (1986) with fistulae | 27 (81) | 27 (67) | 70 | 85 | 40 | 30 | 11 | 7 |
| | 13 | 5 | 77 | 80 | | | | |
| Malangoni (1990) with fistulae | 18 (83) | 30 (43) | 61 | 53 | — | — | 11 | 27 |
| | — | — | | | | | | |
| Hemming (1991) with fistulae | 42 (–) | 41 (–) | 93 | — | 29 | 26 | 12 | 14 |
| | 6 | 6 | 100 | 66 | | | | |
| Levison (1991) with fistulae | 45 (100) | 46 (100) | 47 | 54 | — | — | 29 | 28 |
| | 11 | 10 | 73 | 70 | | | | |
| Bufalari (1996) with fistulae | 27 (100) | 10 (100) | 85 | 80 | 11 | 40 | 11 | 20 |
| | 5 | 3 | | | | | | |
| Jawhari* (1998) with fistulae | 8 (0) | 28 (14) | 50 | 57 | 50 | 43 | 0 | 0 |
| | 3 | 28 | | | | | | |
| Total with fistulae | 284 | 400 | 71 | 73 | 24 | 30 | 13 | 17 |
| | 52 | 60 | 83 | 72 | | | | |
| Authors' data | 359 (100) | 327 (100) | 69 | 62 | — | — | 4.2 | 14.6 |

| | PD (%postoperative) | SD (%postoperative) | Success (%) | | Morbidity (%) | | Mortality (%) | |
|---|---|---|---|---|---|---|---|---|
| | | | PD | SD | PD | SD | PD | SD |
| | 229 | 288 | | | | | | |

[*] Study confined to patients with Crohn disease.

[†] Based on information presented in article if not otherwise stated.

[‡] Mortality per patient if not reported thus in primary literature.

PD, percutaneous drainage; SD, surgical drainage.