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Original Paper

Drain Failure in Intra-Abdominal Abscesses Associated with Appendicitis

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Abstract

Background: Previous studies have suggested that percutaneous drainage and interval appendectomy is an effective treatment for appendicitis with associated abscess. Few studies to date have analyzed risk factors for failed drain management. We hypothesized that older patients with more co-morbidities would be at higher risk for failing conservative treatment.

Methods: The 2010–2014 editions of the National Inpatient Sample (NIS) were queried for patients with diagnoses of peri-appendiceal abscesses. Minors and elective admissions were excluded. We identified patients who underwent percutaneous drainage and defined drain failure as undergoing a surgical operation after drainage but during the same inpatient visit to assess for factors associated with failure of drainage alone as a treatment. After univariable analysis, binomial logistic regression was used to assess for independent risk factors. Frequencies were analyzed by χ^2 and continuous variables by Student's *t*-test.

Results: A total of 2,209 patients with appendiceal abscesses received drains; 561 patients (25.4%) failed conservative management and underwent operative intervention. On univariable analysis, patients who failed conservative management were younger, more likely to be Hispanic, have more inpatient diagnoses, and to have undergone drainage earlier in the hospital course. Multivariable regression demonstrated that the number of diagnoses, female sex, and Hispanic race were predictive of failure of drainage alone. Older age, West and Midwest census regions, and later drain placement were predictive of successful treatment with drainage alone. Failure was associated with more charges and longer hospital stay but not with a higher mortality rate.

Conclusion: Approximately a quarter of patients will fail management of appendiceal abscess with percutaneous drain placement alone. Risk factors for failure are patient complexity, female sex, earlier drainage, and Hispanic race. Failure of drainage is associated with higher total charges and longer hospital stay; however, no change in the mortality rate was noted.

Keywords: appendicitis; intra-abdominal abscess; intra-abdominal infection; perforated appendicitis; peri-appendiceal abscess

Acute appendicitis remains the one of the most common general surgical emergencies in the United States, with an incidence of 9.4–11 per 10,000 person-years [1,2]. Approximately 4%–20% of patients will present with a peri-appendiceal abscess or phlegmon [3,4]. Non-operative therapy for these cases of complicated appendicitis was first advocated as early as 1945 but has remained controversial until recently, when conservative treatment of periappendiceal abscesses has been shown to have fewer complications than immediate appendectomy with no change in antibiotic use or length of stay [3,5–10]. These patients are frequently treated with image-guided drainage of their periappendiceal abscesses and interval appendectomy at a later date because of the lower rates of complications associated with conservative management compared with immediate operation [3,4]. Percutaneous drainage (PCD) of periappendicular abscesses and phlegmons as first-line therapy is recommended by the World Society of Emergency Surgery and the Surgical Infection Society [11,12].

Drains generally are well tolerated but can lead to bleeding, fistula formation, or inadvertent misplacement into surrounding structures [13]. Previous work has shown drain failure rates ranging from 4.5%–26% in adults with intra-abdominal abscesses associated with appendicitis [3,4]. Despite this high rate, there have been minimal efforts to evaluate risk factors for failure of image-guided drainage of

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periappendiceal abscesses in adults. We hypothesized that older, sicker patients would be at greater risk of failing drain management of their appendicitis-associated peritoneal abscess.

Patients and Methods

The 2010–2014 National Inpatient Sample was queried for all cases of adults (age 18 years and greater) with a principal diagnosis of appendicitis and associated peritoneal abscess (International Classification of Diseases [ICD] ICD-9 540.1). Elective admissions, missing procedural data, and inter-hospital transfer cases were excluded. The Elixhauser Co-Morbidity Indices were calculated via publically available software as previously described, and the van Walraven index also was calculated [14–16].

We identified patients who underwent PCD using ICD-9 procedure code 54.91. Patients were defined as having undergone operative management if they underwent an appendectomy or a colorectal procedure (colostomy, colorectal resection, local excision of large-intestine lesion or other lower-gastrointestinal therapeutic procedures) on the basis of the presence of one or more procedure ICD-9 codes (see Supplemental Table 1).

''Successful'' drainage was defined as cases of PCD and no operative intervention during that inpatient stay. ''Failure'' of drainage was defined as PCD and operative intervention on the same day or later in the same hospital stay. Chi-square tests were used to determine associations between categorical variables. Continuous variables were compared by the Student *t*-test. Binomial logistic regression was used to identify risk factors for failure of PCD in patients with appendicitis with abscess. We report the adjusted odds ratios (ORs) and 95% confidence intervals (CIs). All statistical analyses were performed using SPSS version 23.0 (IBM Corp., Armonk, NY, 2015).

Table 1. Demographics and Univariable Analysis of Patients Treated for Acute Appendicitis with Associated Peritoneal Abscess[a]

	Overall (n = *2,209*)	*Success* (n = *1,648*)	*Failure* (n = *561*)	*p*
Age	50.5 (18.5)	51.1 (18.4)	48.7 (18.7)	**0.009**
Gender (%)				0.071
Male	1,154 (52.2)	880 (53.4)	274 (48.8)	
Female	1,052 (47.6)	767 (46.4)	285 (50.8)	
Unknown	3 (0.1)	1 (0.0)	2 (0.3)	
Race (%)				**0.010**
Caucasian	1,329 (60.2)	991 (60.1)	338 (60.2)	
Black	242 (11.0)	185 (11.2)	57 (10.2)	
Hispanic	306 (13.9)	203 (12.3)	103 (18.4)	
Asian or Pacific Islander	90 (4.1)	73 (4.4)	17 (3.0)	
Native American	6 (0.3)	3 (0.2)	3 (0.5)	
Other	64 (2.9)	50 (3.0)	14 (2.5)	
Unknown	172 (7.8)	143 (8.7)	29 (5.2)	N/A
Payor status (%)				0.211
Medicare	531 (24.0)	406 (23.6)	125 (22.3)	
Medicaid	253 (11.5)	191 (11.6)	62 (11.1)	
Private insurance	964 (43.6)	701 (42.5)	263 (46.9)	
Self-pay	323 (14.6)	249 (15.1)	74 (13.2)	
No charge	44 (2.0)	28 (1.7)	16 (2.9)	
Other	89 (4.0)	69 (4.2)	20 (3.5)	
Unknown	5 (0.2)	4 (0.2)	1 (0.2)	
No. of diagnoses	6.47 (5.204)	6.13 (4.9)	7.49 (5.8)	**<0.001**
Elixhauser Index	1.91 (4.52)	1.82 (4.47)	2.17 (4.65)	0.119
Hospital census region (%)				**0.011**
Northeast	487 (22.0)	351 (21.3)	136 (24.2)	
Midwest	433 (19.6)	345 (20.9)	88 (15.7)	
South	765 (34.6)	551 (33.4)	214 (38.1)	
West	524 (23.7)	405 (24.3)	123 (21.9)	
Drain day	1.42 (2.08)	1.61 (2.14)	0.89 (1.80)	**<0.001**

[a]Statistically significant differences are in **boldface** type.

Results

We identified 21,952 cases of appendicitis with peritoneal abscess. Only 10% of these cases (n = 2,209) met our criteria for abscesses with PCD as primary management (Table 1). To determine the efficacy of PCD in the management of appendicitis with associated abscess, we compared patients who had ''successful'' PCD, defined as use of a drainage procedure alone, with cases of ''failed'' PCD, defined as a case that required operative intervention during the same hospital stay after a PCD procedure. We found that 25% (n = 561) of cases of appendicitis initially managed with drainage required operative intervention during the same inpatient stay. The average drain failed 1.0 day (±3.0 days) after placement. There were 630 operations in the 561 patients who failed drain management. Most operations were appendectomies (494; 78.4%). A complete list of procedures is available in Supplemental Table A.

Failure of PCD alone was associated with younger age, Hispanic race, a higher number of inpatient diagnoses, and earlier drain placement (Table 1).

To determine which factors were independently associated with failure of PCD, we performed multivariable logistic regression. We measured the contribution of age, gender, race, Elixhauser/van Walraven Co-Morbidity Index, number of inpatient diagnoses, day of drainage procedure, payor status, and hospital census region. Female sex, younger age, Hispanic race, earlier drainage, and number of hospital diagnoses all were independent risk factors for failure of PCD alone as therapy for appendicitis with associated peritoneal abscess (Table 2). We also found that there were geographic differences in the success rate of drainage alone as a treatment strategy, with the West and Midwest census regions independently associated with a lower risk of failure of drainage alone (Table 2).

We were concerned that reported early failure of drainage represented an error in coding and that operation on the day of drainage may have represented placement of a drain at the time of an operation. We therefore performed repeated binary logistic regression after excluding patients who underwent an operation on the same day they underwent PCD. After excluding these patients, female sex, earlier drainage, younger age, and more hospital diagnoses remained independent risk factors for failure. Census region and Hispanic race became non-predictive. Self-pay status was associated with successful drain management.

To determine the consequence of failure of drainage, we compared the outcomes of successful vs. failed drainage, primary operative management, and no intervention. Although limited outcomes measures are available from these administrative data, we were able to measure length of stay, hospital charges, and deaths. We found that failure of drain management was associated with higher hospital charges ($41,383 ± 37,282 versus $81,930 ± 117,925; $p < 0.001$) and longer hospital stay

Table 2. Binomial Logistic Regression of Risk Factors for Failure of Drain Management

	Odds ratio	*95% Confidence interval*	p
Age (years)	0.982	0.975, 0.990	**<0.001**
Sex (male)			**0.009**
Female sex	1.250	1.022, 1.528	**0.030**
Unknown sex	17.06	1.46, 199.2	**0.024**
Elixhauser index (van Walraven modification)	0.991	0.966, 1.017	0.496
Day of drainage procedure	0.757	0.704, 0.813	**<0.001**
Number of hospital diagnoses	1.103	1.076, 1.131	**<0.001**
Insurance (Medicare)			0.105
Medicaid	0.760	0.492, 1.174	0.216
Private insurance	1.108	0.794, 1.546	0.547
Self-pay	0.774	0.509, 1.177	0.231
No charge	1.532	0.738, 3.180	0.253
Other	0.736	0.399, 1.359	0.328
Unknown	0.711	0.076, 6.677	0.765
Race (Caucasian)			**0.011**
Black	0.831	0.588, 1.173	0.292
Hispanic	1.633	1.209, 2.207	**0.001**
Asian or Pacific Islander	0.826	0.469, 1.456	0.509
Native American	3.098	0.557, 17.234	0.196
Other	0.793	0.421, 1.491	0.471
Unknown	0.991	0.618, 1.589	0.970
Census Region (Northeast)			**0.009**
Midwest	0.603	0.432, 0.844	**0.003**
South	0.868	0.659, 1.142	0.311
West	0.681	0.503, 0.922	**0.013**

[a]Statistically significant differences are in **boldface** type.

(6.1 ± 4.7 days versus 8.7 ± 9.0 days; $p < 0.001$) but was not associated with a higher mortality rate (0.55% versus 0.71%; $p = 0.65$) (Table 3).

Discussion

Although early surgical therapy remains the standard of care for appendicitis, there remains controversy on the treatment of patients who present with associated abscesses. Several meta-analyses have concluded that non-operative therapy is superior to early intervention in these cases [3,8]. Although studies have been conducted in children, with conflicting results, there are few data to guide therapy in adults [17–19]. The studies that have analyzed risk factors in adults generally have been single center and retrospective and enrolled fewer than 100 patients, thus limiting their power and the generalizability of the results [4,18,20,21].

Table 3. Outcomes of Patients Undergoing Percutaneous Drainage for Periappendiceal Abscesses[a]

	Overall	*Success*	*Failure*	p
Length of stay (d)	6.8 (6.2)	6.12 (4.7)	8.7 (9.0)	**<0.001**
Total charges (US$)	51,885 (70,302)	41,384 (37,282)	81,930 (117,925)	**<0.001**
Deaths (%)	13 (0.6)	9 (0.5)	4 (0.7)	0.65

[a]Statistically significant differences are in **boldface** type.

To select cases of periappendiceal abscesses associated with appendicitis, we included only cases where periappendiceal abscess was the ''principal diagnosis,'' defined as ''the condition established after study to be chiefly responsible for occasioning the admission of the patient to the hospital for care'' [22]. This rule excludes patients with abscesses found incidentally or not related to appendicitis. We further ensured that we enrolled patients with abscesses by not including ICD-9 code 540.0, appendicitis with peritonitis, which could represent a range of disease from localized peritonitis to free perforation. After selecting patients with periappendiceal abscesses, we chose to tally only those who underwent drainage, with the goal of ensuring that only patients with true abscesses were included. We sought to be inclusive in our definition of an ''operation,'' in order not to exclude complex cases. We therefore included patients who underwent any surgical operation that could have resulted in removal of the appendix, including, but not limited to, appendectomy (although appendectomies represented 78.4% of all operations; see Supplemental Table A). Our overall low mortality and failure rates, similar to those in prior studies, suggests that we were successful in our selection [4,18,20,21].

Our data suggest that patients who are Hispanic, female, younger, receive drains early, and are more complex medically, as measured by the number of inpatient diagnoses, are more likely to fail drain management. Although the finding that patients with more inpatient diagnoses are more likely to fail such management was expected, the other results were not. Several prior studies have shown that patients who fail non-operative management are younger, but the values did not reach statistical significance, likely because of the small volume of patients [4,18,20,21]. In our analysis, ''drain failure'' is defined as a requirement for an operation after drain placement during the same hospital stay. The age difference we detected may reflect a hesitation to operate on elderly patients (or a willingness to operate on younger patients), skewing the age difference for ''failure'' younger. It is unclear why patients who have drains placed earlier are more likely to fail conservative therapy. It is possible that these patients present with more advanced disease and require earlier drainage because of the severity of their condition. However, we lack sufficient data in the NIS to determine whether this is the case. The fact that Hispanic patients have a higher failure rate is potentially explained by presentation late in the disease course. Multiple factors have been studied that could contribute to this result, including language barrier and cultural and insurance reasons. A previous study by Flores found that language barriers may play a role in the higher rate of Hispanic patients failing drainage [23]. In addition, data from the 2010 census suggests that Hispanic patients are less likely to seek medical attention than are other patient groups [24]. As such, Hispanic patients may present later than other racial groups and therefore be at higher risk for drainage failure.

The finding that female patients have higher failure rates than males is surprising to us, especially in light of the lack of a significant difference on univariable analysis. This suggests that there may be confounding factors not accounted for in the

NIS. There has been no previous literature describing this phenomenon, either specific to abscesses associated with appendicitis or to intra-abdominal abscesses in general, with the exception of a single series that demonstrated a trend toward a higher rate of failure in women [21]. We hypothesize that this finding is related to the more complex pelvic anatomy, making percutaneous drainage technically more difficult. We are unable to assess this hypothesis with the current dataset. Our findings regarding higher failure rates in the West and Midwest of the United States are similar to prior work in the pediatric population, which demonstrated a higher risk of complications from appendicitis in the same geographic regions. An explanation for this finding remains unclear [25]. Similar to prior studies, failure of drain management was associated with the greater length of stay compared with successful minimally invasive management [4].

Our study has several limitations. First, there are several important limitations inherent in using administrative data, including the potential for miscoding or misdiagnoses. Previous studies have shown heterogeneity between states depending on the coding strategy used, which has the potential to skew results [26]. We attempted to exclude patients with phlegmons by excluding the heterogenous ICD9 code 540.0, acute appendicitis with peritonitis, which could contain a spectrum of disease from localized peritonitis to intestinal rupture. However, there is the potential for miscoding, which could skew our data in ways we are unable to account for. We attempted to compensate by analyzing only patients who underwent drainage during admission, as we believe these patients were more likely to have abscesses rather than phlegmons. Previous series have demonstrated that larger abscesses, poorly defined abscesses, and abscesses with extraluminal appendicoliths are at higher risk of failure [17,18,21]. We are unable to provide descriptions of morphology or number of abscesses present because of the limitations of the NIS. Finally, we were limited in our outcome measures to length of stay, mortality rate, and total charges.

Despite the limitations inherent in the use of an administrative dataset, these results are an important addition to the literature on abscesses associated with appendicitis. Clearly, further research into risk factors for failure of drain management is needed in order to put these results in context and characterize further the patients at risk of failed conservative management.

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Author Disclosure Statement

No competing financial interests exist for any of the authors.

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