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Does retrieval bag use during laparoscopic appendectomy reduce postoperative infection?

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ABSTRACT

Background: Appendectomy is the most commonly performed emergency operation in the United States, with approximately 370,000 patients undergoing the procedure every year. Although laparoscopic appendectomy is associated with decreased complications when compared with open appendectomy, the risk for infectious complications, including surgical site infection, intra-abdominal abscess, and sepsis, remains a significant source of postoperative morbidity and health care cost. The goal of this study is to determine whether the appendix retrieval technique during laparoscopic appendectomy affects risk of infectious complications.

Methods: The American College of Surgeons National Surgical Quality Improvement Program database and the Appendectomy Procedure Targeted database were used to conduct this retrospective study. Patients who underwent laparoscopic appendectomy in 2016 were identified. The primary outcomes were infectious complications of superficial site infection and intra-abdominal abscess.

Results: A total of 10,578 (92.2%) patients underwent laparoscopic appendectomy using an appendix retrieval bag and 897 (7.8%) patients underwent laparoscopic appendectomy without an appendix retrieval bag. There was no significant difference in preoperative sepsis, smoking status, wound class, complicated appendicitis, or American Society of Anesthesiologists class between patient groups (all $P > .05$). In the univariate analysis, there was no difference in the rate of superficial site infection (0.9% vs 0.6%, $P = .28$) or intra-abdominal infection (2.7% vs 3.8%, $P = .06$) between retrieval bag use and non-use. In the multivariable analysis, appendix retrieval bag use was an independent predictor of intra-abdominal infection and associated with a 40% decrease in intra-abdominal infection rates (odds ratio: 0.6, 95% confidence interval: 0.42–0.95, $P = .03$).

Conclusion: Appendix retrieval bags are associated with a decreased risk of postoperative intra-abdominal abscess. The use of appendix retrieval bags should be the standard of care during laparoscopic appendectomy.

Introduction

Appendectomy is the most commonly performed emergency operation in the United States, with approximately 370,000 patients undergoing the procedure every year.[1] Appendectomy is most commonly performed for acute appendicitis.[2,3] Laparoscopic appendectomy has largely replaced open appendectomy in recent years, accounting for 75% of appendectomies performed in 2011.[1] Compared with open appendectomy, laparoscopic appendectomy is associated with shorter length of hospital stay, decreased postoperative pain, quicker recovery time, reduced superficial surgical site infection, and reduced postoperative ileus.[4–8]

Although laparoscopic appendectomy is associated with decreased complications overall when compared with open appendectomy, the risk for infectious complications, including surgical site infection, intra-abdominal abscess, and sepsis, still persists. Some studies suggest a two- to three-fold increased risk of postoperative organ space infection with laparoscopic appendectomy compared with open appendectomy.[7–10] Previous studies inves-

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tigating risk factors for infection after laparoscopic appendectomy have described increased risk with complicated appendicitis, greater duration of symptoms, and elevated admission white blood cell count.[11–14] However, few studies have assessed operative technique as a potential risk factor. Earlier reports have studied irrigation and found that intraoperative irrigation for perforated appendicitis did not reduce the rates of intra-abdominal abscess.[15]

During laparoscopic appendectomy, the appendix is typically removed from the abdominal cavity using specimen retrieval bags or by direct extraction through the instrument trocar or incision sites.[16] Use of either retrieval technique is institution dependent and surgeon dependent. Use of retrieval bags may lengthen the operative time and increase the cost of the procedure. There have been few single-institution studies focused on pediatric populations that have investigated the implications of appendix retrieval technique via specimen retrieval bag or direct extraction on infectious complications.[17]

The goal of this study is to investigate whether the use of appendix retrieval bags during laparoscopic appendectomy is associated with the risk of infectious complications. This investigation was carried out using the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) database.

Methods

Data source and patient selection

The ACS NSQIP Procedure Targeted Appendectomy database from 2016 was queried. The procedure-targeted database contains 12 variables related to appendectomy outcomes, such as the use of appendix retrieval bags, operative approach, and occurrence of intra-abdominal infection. ACS NSQIP is a validated, risk-adjusted, prospectively collected national database, which provides information on patient demographics, medical comorbidities, operative variables, and postoperative outcomes. Further details of the ACS NSQIP are described elsewhere.[18] Patients were included in the analysis if they underwent laparoscopic appendectomy identified using Current Procedural Terminology code 44970. Patients with missing information on the presence or absence of intra-abdominal abscess were excluded from the analysis. These data were then merged with the general ACS NSQIP database for further analysis. The study was reviewed and deemed exempt by the Institutional Review Board.

Variables and outcomes

An appendix retrieval bag was defined as "appendix placed in a specimen bag prior to removal" for laparoscopic appendectomy.[19] Intra-abdominal abscess was defined as a postoperative intra-abdominal abscess that required no further treatment, antibiotics, percutaneous drainage, or operative intervention. Complicated appendicitis was defined as appendix with evidence of perforation or abscess. We recorded demographic, preoperative, operative, and postoperative variables for the analysis. Demographic factors included age, race, gender, body mass index, and American Society of Anesthesiologists (ASA) class. Medical comorbidities, such as diabetes, hypertension, and chronic obstructive pulmonary disease, were collected. Preoperative factors, such as white blood cell count and preoperative sepsis, were recorded. Operative factors included wound class, operative time, and pathologic classification of the appendix.

The primary outcomes of interest in our study were infection rates, specifically superficial site infection and intra-abdominal abscess. Secondary outcomes included occurrence of postoperative sepsis or septic shock, reoperation, and hospital readmission within 30 days of the index procedure.

Statistical analyses

Descriptive statistics were used to compare demographic, preoperative, operative, and postoperative variables between groups. Categorical variables were compared using the Fisher exact test and are expressed using percentages. Continuous variables were compared using two independent-sample *t* tests and the Wilcoxon rank sum tests, expressed as medians with interquartile range or mean with standard deviation. Multivariable logistic regression was then performed. Variables with $P < .10$ in the univariate analysis were used in the multivariable model. $P < .05$ was considered statistically significant for all tests run. Two-sided *P* values are presented for tests. All statistical analyses were conducted using SPSS software version 20.0 (SPSS Inc, Chicago, IL).

Results

Baseline characteristics

A total of 11,475 patients were identified who underwent laparoscopic appendectomy. We noted that 10,500 (91.5%) had a confirmed pathologic diagnosis of appendicitis. A total of 10,578 (92.2%) patients underwent laparoscopic appendectomy with an appendix retrieval bag and 897 (7.8%) patients underwent laparoscopic appendectomy without an appendix retrieval bag. The demographics, medical comorbidities, and procedure characteristics for the two groups are summarized in Table 1. There was no significant difference in age, smoking status, steroid use, preoperative sepsis, operation wound class, ASA class, operation time, and complicated appendicitis between the two groups of patients (all $P > .05$). Patients in the no retrieval bag group compared with the retrieval bag group were more likely to be female, have lower body mass index (BMI), and have lower preoperative white blood cell count (all $P < .05$), although these differences were small.

Outcomes—univariate analysis

The overall incidence of superficial site infection and intra-abdominal abscess was 0.9% and 2.8%, respectively (Table 2). In the univariate analysis, there was no difference in the rate of superficial site infection in patients undergoing appendectomy without a retrieval bag versus using a retrieval bag (0.6% vs 0.9%, $P = .28$). There was a trend toward a higher rate of intra-abdominal infection in patients undergoing appendectomy without a retrieval bag compared with patients undergoing appendectomy with a retrieval bag (3.8% vs 2.7%, $P = .06$). There was no significant difference in the rate of postoperative sepsis or septic shock (3.9% vs 3.3%, $P = .26$), reoperation (1.3% vs 1.0%, $P = .32$), or readmission (3.6% vs 3.8%, $P = .77$) between patient groups.

Outcomes—multivariable analysis

In the multivariable analysis, use of an appendix retrieval bag was an independent predictor of decreased intraabdominal abscess (odds ratio [OR]: 0.6, 95% confidence interval [CI]: 0.42–0.95, $P = .03$). Use of a retrieval bag was associated with a 40% decrease in intra-abdominal infection. This corresponds to a number needed to treat of 91 to prevent 1 additional intra-abdominal abscess. Independent predictors of increased infection included diabetes (OR: 1.6, 95% CI: 1.03–2.58, $P = .04$), preoperative sepsis (OR: 2.1, 95% CI: 1.62–2.74, $P < .0001$), complicated appendicitis (OR: 8.9, 95% CI: 6.72–11.99, $P < .0001$), and male sex (OR: 1.4, 95% CI: 1.07–1.81, $P = .01$) (Table 3).

Table 1
Patient characteristics.

	No retrieval bag ($n = 897$)	Retrieval bag ($n = 10,578$)	*P* value
Demographics			
Age, years	35 (25–49)	36 (26–51)	.16
Female	476 (53.1%)	5,175 (48.9%)	.02
Body mass index (kg/m^2)	27.8 ± 6.7	28.4 ± 6.7	.02
Race			.03
White	523 (58.3%)	6,661 (63.0%)	
Black	70 (7.8%)	781 (7.4%)	
Asian	31 (3.5%)	371 (3.5%)	
Other	273 (30.4%)	2,765 (26.1%)	
Comorbidities			
Diabetes	31 (3.5%)	532 (5.0%)	.04
Hypertension	125 (13.9%)	1,623 (15.3%)	.26
Chronic obstructive pulmonary disease	1 (0.1%)	105 (1.0%)	.01
Smoker	144 (16.1%)	1,746 (16.5%)	.73
Independent functional status	892 (99.7%)	10,519 (99.7%)	.83
Steroid use	12 (1.3%)	155 (1.5%)	.76
Weight loss	2 (0.2%)	26 (0.2%)	.89
Preoperative sepsis	251 (28.0%)	3,275 (31.0%)	.06
Procedure characteristics			
Wound class 3/4	668 (74.5%)	7,907 (74.7%)	.85
Complicated appendicitis	186 (20.6%)	2,300 (21.6%)	.49
ASA class 3/4	147 (16.4%)	1,604 (15.3%)	.37
Operation time, minutes	51.1 ± 36.5	52.3 ± 34.3	.33
Preoperative labs			
White blood cell (mg/dL)	12.2 ± 4.4	12.6 ± 4.5	.01

Table 2
Postoperative complications

	No retrieval bag ($n = 897$)	Retrieval bag ($n = 10,578$)	*P* value
Superficial infection	5 (0.6%)	96 (0.9%)	.28
Intra-abdominal abscess	34 (3.8%)	286 (2.7%)	.06
Sepsis/septic shock	36 (3.9%)	350 (3.3%)	.26
Reoperation	12 (1.3%)	105 (1.0%)	.32
Readmission	32 (3.6%)	398 (3.8%)	.77

Table 3
Independent risk factors for intraabdominal abscess

	OR	95% CI	*P* value
Older age	0.99	0.99–1.00	.12
Body mass index	1.0	0.99–1.03	.46
Male sex	1.4	1.07–1.81	.01
Diabetes	1.6	1.03–2.58	.04
ASA class	1.4	0.99–2.01	.06
Preoperative sepsis	2.1	1.62–2.74	< .001
Complicated appendicitis	8.9	6.72–11.99	< .001
Retrieval bag	0.6	0.42–0.95	.03

Characteristics of intra-abdominal infection

Of the patients developing intra-abdominal abscess, 128 patients (40%) required either percutaneous intervention or operative intervention. A total of 212 (60%) required oral or intravenous antibiotics or no intervention.

Discussion

Appendectomy has been the treatment of choice for acute appendicitis since its description in 1894 by McBurney.[20] It has now become one of the most common surgical procedures performed, with 7% of the population undergoing an appendectomy during their lifetime.[2] In 1983, laparoscopic appendectomy was described and has since replaced open appendectomy as the gold standard treatment for acute appendicitis.[21] Although laparoscopic appendectomy has a lower wound infection rate than open appendectomy, the incidence of intra-abdominal abscess still remains higher for the laparoscopic technique.[8] Given the high volume of cases in the United States, it is important to identify ways to reduce infection rates. One way to reduce infection is to standardize preoperative treatment and operative technique based on evidence-based practices. For example, perioperative antibiotics can reduce the rate of postoperative infection after appendectomy.[22] Unfortunately, there is limited evidence regarding specific operative technique or device utilization that has been shown to decrease infection rates. As a result, there remains variation in laparoscopic appendectomy operative technique, likely stemming from surgeon preference, training, and available equipment.

Therefore, in this study we used the NSQIP database to determine whether technique during laparoscopic appendectomy, specifically use of an appendix retrieval bag, was associated with postoperative infection. This is the largest and one of the first studies to date to assess this clinical question. The present study showed that the majority of patients underwent laparoscopic appendectomy with the use of an appendix retrieval bag (92%) and 7.8% of patients underwent laparoscopic appendectomy without the use of an appendix retrieval bag. A total of 2.8% of patients developed an intra-abdominal infection after surgery. Use of a retrieval bag during laparoscopic appendectomy reduced intra-abdominal infection by 40%. The rate of intra-abdominal abscess in this study is similar to owther investigations, which report rates of postoperative intra-abdominal abscess from 1.6% to 3.5%.[11,23–24] The reason for this decreased risk of intra-abdominal abscess with retrieval bag use is not fully known but is likely attributable to a decreased contamination of the abdominal cavity. Extrapolating from earlier studies,[25] the use of a retrieval bag may reduce bacterial contamination that would otherwise occur during irrigation or manipulation of an uncovered appendix.

In two recent studies of laparoscopic appendectomy in pediatric patients, approximately 80%–90% of patients underwent laparoscopic appendectomy with use of a specimen retrieval bag.[26–27] The goal of both studies was to standardize operative care by instituting an operating room preference card or by giving feedback on cost and outcomes. In the first study, as there was no evidence for utilizing a retrieval bag, it was removed from the new standard operating room preference card and the rate of use dropped to 60%. After this implementation, the surgeons noted a trend toward increased intra-abdominal infection. In the second study, the rate of retrieval bag use dropped to 43% by the end of the study, with 35% of patients having the appendix removed directly through the incision site. This study similarly reported a trend toward increased surgical site infections after the intervention. Of note, 80% of the cases with a surgical site infection had not used a retrieval bag. One single-institution study to date has directly assessed infection rates in patients undergoing laparoscopic appendectomy with and without an appendix retrieval bag. The study found an increased risk of incisional site infection and intra-abdominal abscess in patients undergoing laparoscopic appendectomy without a retrieval bag.[17]

Although the incidence of surgical site infections is low after laparoscopic appendectomy, it is associated with increased cost, pain, and length of stay.[28] The estimated cost of any surgical site infection is $20,785, and the projected annual cost for surgical site infections across surgery is more than $3.3 billion.[29] Hospital length of stay and additional procedures contribute to this cost. In our study, 40% of patients with intra-abdominal abscess required operative or percutaneous intervention. The cost of an appendix retrieval bag is approximately $50.[27] In our study we found the number needed to treat was 91. Therefore, by spending $4,550 on appendix retrieval bags for 91 patients, one could save $16,235 by preventing 1 postoperative intra-abdominal abscess. Extrapolating this out to the approximate 370,000 patients undergoing appendectomy each year in the United States, spending $18.5 million on appendix retrieval bags could save $66 million related to postoperative infection each year.

This study and others document that 7%–20% of cases do not use retrieval bags.[26–27] However, the majority of cases do involve appendix retrieval bags, as shown in this study. Reasons for not using the device may include the surgeon comfort with the instrument, the goal of minimizing upfront procedure cost, or the additional operating time needed to use the device. Of note, there was no significant difference in operation time between patients undergoing laparoscopic appendectomy with or without retrieval bag use in our study. In fact, the average operating time was only 1 minute more in the retrieval bag group. Given the reduction in infection rate and potential overall cost savings, use of the device appears to outweigh the potential negatives of the instrument use.

This study also demonstrated that other factors contributed to postoperative intra-abdominal infection, specifically diabetes, preoperative sepsis, complicated appendicitis, and male sex. Other studies have shown that these factors are associated with postoperative infections after laparoscopic appendectomy.[10,24,30] Ensuring perioperative blood sugar control and administering timely antibiotics are interventions directly related to the modifiable risk factors identified in this study that can be used to decrease postoperative infection. Of note, there was no difference in the rate of superficial site infection related to appendix retrieval bag use. Overall, the rate of superficial site infection was low at 0.9%. Earlier studies have reported similar rates of superficial site infection ranging 1.7%–2.5%.[11,24] It is unknown whether other techniques were used to try to prevent incisional site infection when an appendix retrieval bag was not used, such as antiseptics, specimen removal through a trocar, or removal with a sterile glove covering.

This study has several strengths. First, this is the first study to assess the association of retrieval bags and the infection rate in adult patients undergoing laparoscopic appendectomy. Second, the ACS NSQIP database is a multicenter, national, prospectively collected database with audits on data collection, making the patient data both generalizable and reliable. Third, this is the largest study to focus on this clinical question, and given our sample size, we are adequately powered to detect a difference in small infection rates. Fourth, this study utilized information from both the appendectomy-specific database and the general NSQIP database, allowing us to assess more granular risk factors and outcomes related to appendectomy. However, this study is not without limitations. First, this study is retrospective in nature and thus we are unable to draw causal conclusions between retrieval bag use and infection rates. Given the retrospective nature of the investigation, we are unable to determine why surgeons did or did not use for appendix retrieval bags; however, our two patient groups were similar at the baseline. Second, the database does not collect all variables relating to postoperative infection, such as perioperative antibiotic administration or specific appendectomy techniques such as irrigation. It is important to understand whether antibiotic protocols were followed because this has been shown to reduce postoperative infection but this is a limitation of what is recorded in the NSQIP database; however, it is unlikely that there is differential adherence to antibiotic protocols between operative technique groups. Third, it is possible that some patients with a postoperative infection presented to hospitals other than where the index operation was performed and, therefore, infection rates are underreported.

In conclusion, use of an appendix retrieval bag is associated with decreased intra-abdominal abscess. Diabetes, preoperative sepsis, complicated appendicitis, and male sex were independent predictors of postoperative intra-abdominal abscess. Postoperative intra-abdominal abscess can be reduced by 40% with the use of appendix retrieval bags and this can lead to significant cost savings. Given the benefit of retrieval bag use, standardization of laparoscopic appendectomy can begin with this evidence-based technique.

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