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A call for a standardized definition of perforated appendicitis

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Abstract

Background—Abscess rates have been reported as low as 1% and as high as 50% following perforated appendicitis (PA). This range may be due to lack of universal definition for PA. An evidence-based definition (EBD) is crucial for accurate wound classification, risk-stratification, and subsequent process optimization. ACS NSQIP – Pediatric guidelines do not specify a definition of PA. We hypothesize reported post-operative abscess rates underrepresent true incidence, as they may include low-risk cases in final calculations.

Methods—Local institutional records of PA patients were reviewed to calculate the post-operative abscess rate. The ACS NSQIP – Pediatric participant use file (PUF) was used to determine cross-institutional post-operative abscess rates. A PubMed literature review was performed to identify trials reporting PA abscess rates, and definitions and rates were recorded.

Results—20.9% of our patients with PA developed a postoperative abscess. The ACS NSQIP – Pediatric abscess rate was significantly lower (7.61%, $p < 0.001$). In the eighteen published studies analyzed, average abscess rate (14.49%) was significantly higher than ACS NSQIP – Pediatric ($p < 0.001$). There was significantly more variation in trials that do not employ an EBD of perforation (Levene's test F -value = 6.980, $p = 0.018$).

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Author contributions

Dr. Rogers was the primary author who conducted this research under the guidance of Dr. Charles Leys, Dr. Peter Nichol, and Dr. Daniel Ostlie. Dr. Zens provided assistance with regards to chart review and data interpretation. All authors were involved in critical revision of the manuscript.

Level of Evidence: III

Conflicts of Interest: Dr. Nichol is a member of the scientific advisory board for MedAware Systems Inc. Dr. Ostlie is a consultant for JustRight Inc. Neither of these conflicts relates to the subject material of this manuscript.

Disclaimer

With regard to data from the PUF, *the American College of Surgeons National Surgical Quality Improvement Program and the hospitals participating in the ACS NSQIP Pediatric are the source of the data used herein; they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors. Additional PUF guidelines apply and can be found in the DUA: <https://www.facs.org/~media/files/quality%20programs/nsqip/pedsdataagreement.ashx>*

Conclusions—A standard EBD of perforation leads to lower variability in reported post-operative abscess rates following PA; nonstandard definitions may be significantly altering the aggregate rate of post-operative abscess formation. We advocate for adoption of a standard definition by all institutions participating in ACS NSQIP – Pediatric data submission.

Keywords

NSQIP; perforated appendicitis; abscess; evidence-based; wound classification

Introduction

Acute appendicitis is one of the most commonly treated conditions in pediatric surgery[1]. Because it is so frequently seen, it offers an excellent opportunity for review and improvement of clinical practices. By using large electronic databases, clinicians and quality improvement researchers can investigate aggregated data from multiple institutions to identify the best practices and benchmarks. One of the most commonly tracked outcomes is the frequency of infectious complications such as post-operative wound infections and intraabdominal abscesses. Previous work has shown that cases where the appendix is perforated (defined as a visualized hole in the appendix or fecalith in the abdomen) are at the greatest risk for developing a post-operative abscess [4]

Currently, ACS-NSQIP does not directly capture data on whether or not the appendix is perforated at the time of an operation for acute appendicitis, nor does it specify a standard, evidence-based definition (EBD) of perforation. [2]. We hypothesize that current ACS-NSQIP guidelines may confound the ability to capture an accurate post-operative abscess rate due to the lack of a standardized definition for perforated appendicitis and inability to distinguish perforation from other complicating findings during appendectomy. This distortion may make subsequent cross-institutional comparisons more difficult, as risk-profiles for different types of appendicitis may be compared inappropriately. Cases that would not be considered perforated under a strict EBD of perforation (i.e. – an appendix described as gangrenous or purulent) are labeled as ‘dirty’ under current guidelines; however, the inclusion of these lower risk cases may be falsely lowering the expected rate of post-operative abscess formation.

The goals of this study are to compare our institutional post-operative abscess rate to that reported in ACS NSQIP – Pediatric data, and also to evaluate definitions of perforation and post-operative abscess rates in published randomized control trials involving perforated appendicitis in the pediatric population.

Methods

Following approval by the University of Wisconsin Institutional Review Board, all cases of acute appendicitis at our institution from January 2013 to June 2015 were reviewed. Cases of perforated appendicitis (with operative note findings consistent with the evidence-based definition) were identified, and the percentage of those cases that were complicated by a post-operative abscess was calculated.

The Participant Use File (PUF)[3] provided by ACS NSQIP – Pediatric was then used to compare institutional data to the experience of all participating institutions. ACS NSQIP – Pediatric identifies appendicitis by wound class. Based on the definitions provided for the wound classes, perforated appendicitis is classified in the ‘dirty’ wound class, while non-perforated appendicitis is classified as ‘contaminated’. We identified all cases of ‘dirty’ wound classes as a proxy for perforation. The post-operative abscess rate for this subset was calculated.

Next, published studies from December 2008 to December 2014 that evaluated post-operative abscess rates following perforated appendicitis in pediatric patients were identified. This period was chosen because it followed the publication of the index study[4] that established either a hole in the appendix or fecalith in the abdomen as guidelines for an evidence-based definition for perforated appendicitis. For each study in the analysis, the number of patients, post-operative abscess rate, and criteria employed to define perforated appendicitis were reviewed. Studies were subsequently sorted into two groups: evidence vs non-evidence based definition of perforated appendicitis; rates and variance were compared across the two groups. All statistical analyses were conducted in SPSS™ v.23 (IBM®, Armonk, New York). Chi-squared and Fisher’s exact tests were used to compare rates, and Levene’s test was used to assess variance. Significance was defined as p-value <0.05.

Results

Institutional data

From January 2013 to July 2015, there were a total of 318 cases of appendicitis at our institution, 86 of which were perforated appendicitis (27% perforation rate); all perforated cases were correctly classified as ‘dirty/infected’. Of these, 18 went on to develop a post-operative abscess, yielding an abscess rate of 20.9%.

National and aggregate data

Using the ACS NSQIP – Pediatric PUF, a total of 4773 cases of acute appendicitis were identified from January 2013 to July 2015. Of these, 1170 (24.5%) were classified as ‘dirty’ wound classification (our proxy for perforation). Although ACS NSQIP does not have a variable to indicate whether an appendix is perforated, standard wound classification definitions indicate only appendicitis cases that have uncontrolled spillage of stool into the abdomen or a visible hole in the appendix are classified as ‘dirty’. Cases where there is no uncontrolled stool spillage or appendiceal perforation are considered ‘contaminated’[5]. Based on these definitions, the wound class ‘dirty’ was used as a proxy for perforation for the purposes of this study. There was no significant difference in the rate of perforation between our institution (27%) and the ACS – NSQIP PUF file (24.5%) ($p = 0.313$). However, the incidence of post-operative abscess in the ACS-NSQIP group was 89 of 1170 (7.61%), significantly lower than our institutional rate (20.9%) ($p < .001$).

Review of the Literature

We identified a total of eighteen studies[4,6–22] that reported post-operative abscess rates in pediatric patients with perforated appendicitis since January 2009. Five of these trials

explicitly employed the evidence-based definition perforated appendicitis, requiring a visualized hole in the appendix or fecal matter in the peritoneal cavity. The other thirteen trials either included criteria beyond the EBD (such as gangrene or purulence) or did not specify the criteria for classification as perforated. The trials and their calculated rates of postoperative abscess are listed in Table 1.

For the trials that employed the EBD, the average rate of post-operative abscess was 18.84%. For trials that did not employ the EBD, the average rate of post-operative abscess was significantly lower at 12.57% ($p < 0.001$). In addition, the post-operative abscess rate calculated across all trials (EBD trials and non-EBD trials combined) is significantly higher than the rate seen in PUF data (14.49% vs 7.62%, $p < 0.001$). Also of note, the reported rates vary significantly more in the non-EBD group than in the EBD group (Levene's test F-value = 6.980, $p = 0.018$) (Figure 1).

Discussion

The American College of Surgeons National Surgical Quality Improvement Program – Pediatric (ACS NSQIP - Pediatric ®) routinely collects information related to rates of post-operative abscess formation, and the risk profiles are stratified based on the wound classification. Operations are classified either as clean, clean contaminated, contaminated, or dirty/infected. These stratifications are based on the degree of intraoperative contamination and represent distinct levels of risk for post-operative wound infection based on that level of contamination[23]. As the amount of contamination increases, the risk of post-operative wound infection also goes up. Rates have been estimated from 1%–5% for clean wounds, 3%–11% for clean/contaminated wounds, 10%–17% for contaminated wounds, and over 27% for dirty/infected wounds[23]. For appendicitis, the wound classification changes depending on whether or not the appendix is perforated. For acute, nonperforated appendicitis, the correct wound classification is contaminated, defined by the ACS NSQIP – Pediatric operations manual as “incisions in which acute, nonpurulent inflammation is encountered, including necrotic tissue without evidence of purulent drainage (i.e.-dry gangrene).”[2] In contrast, a perforated appendicitis is classified as dirty/infected, as the case involves “existing clinical infection or perforated viscera. Examples...include abscess, perforated bowel, peritonitis, ruptured appendix, gangrenous gallbladder.”[2].

Since there is difference in risk of infectious complications between contaminated and dirty/infected wound classifications[23], it is important to properly and consistently classify the type of appendicitis across participating institutions. Various definitions of perforation have been employed clinically, though only a visualized hole in the appendix or fecal contamination of the peritoneal cavity have been shown to correlate with a statistically increased risk of post-operative abscess[4].

The data presented in this study shows the lack of standardized, evidence-based definition for perforated appendicitis increases the variability of the post-operative abscess rate seen in ‘dirty’ or perforated appendicitis cases. This variability may challenge our ability to effectively interpret aggregate data, like that collected by ACS NSQIP – Pediatric. Without access to the criteria used by participating institutions, it is difficult to say exactly what is

being used to define perforation. A limitation of our study is that several of the studies reviewed did not explicitly include a definition of perforated appendicitis. It is possible that the definitions employed by these authors are consistent with the EBD, but this could not be verified from the review of the manuscript.

Several of the studies we reviewed specifically included the presence of purulent fluid or gangrene as satisfactory criteria for perforation. On this subject, ACS NSQIP – Pediatric criteria seem to validate their inclusion in the ‘dirty’ wound class (“existence of clinical infection” and “examples...abscess, peritonitis, and gangren[e]”)[2] though the evidence-based definition does not include these as reliable markers[4]. We believe that the rate of post-operative abscess formation is altered by the inclusion of these cases in the perforated appendicitis group, and advocate for participating institutions to adopt the evidence based definition as a standard for defining appendicitis. The potential for misclassification of perforated appendicitis as a ‘contaminated’ case seems unlikely, as ACS NSQIP – Pediatric guidelines specify that wounds that involve “clinical infection or perforated viscera” are considered ‘dirty’[2]. Coders should not reclassify them as ‘contaminated’ if the operative report does not specify the presence of purulence, as this is not a requirement needed for ‘dirty’ wounds.

On another note, we feel it is appropriate to evaluate whether our current wound classification system would benefit from amendment to optimize risk-stratification. As mentioned previously, perforated appendicitis carries a higher post-operative abscess risk than nonperforated appendicitis; gangrene, purulence, and tissue necrosis have not been shown to increase risk. Studies have shown that incorporating gangrene and perforation in the same category may not be clinically applicable[25–27]. We may be better served to revise classification to capture what we have learned to be clinically meaningful variables.

Previous work has shown that the accuracy of surgical wound classification is poor[5,24]. Without a consistent definition of what constitutes a specific type of surgical wound, our ability to correctly classify operative wounds is further challenged. As cross-institutional collaborations develop, it is critical that the information gathered is as accurate as possible to establish appropriate clinical benchmarks and guide quality improvement projects. In the case of perforated appendicitis, institution of the EBD would eliminate a potentially confounding variable, allowing a more controlled and better interpretation of aggregate results. Additional studies might then be able to investigate other questions related to the treatment of appendicitis. We feel that questions addressing issues such as appropriate antibiotic strategy, the impact of gangrene, tissue necrosis, or purulence on post-operative complications may be more meaningful in the setting of a shared EBD of perforation. By separating these findings, participating institutions can better improve clinical practices

Finally, this study is in no way intended to diminish the remarkable contributions that ACS NSQIP- Pediatric is having with regard to improving the quality of care that pediatric surgery patients are receiving across the United States. Without this program, we would continue to be deficient in our ability to follow the quality of care across institutions. We believe that the concerns raised in this study should be utilized only to provide guidance that has the potential to improve patient care and the ACS NSQIP- Pediatric program.

In conclusion, there is increased variation in the post-operative abscess rate in studies that do not employ an evidence-based definition of perforation. Given these results, we advocate strongly for the dissemination and adoption of the EBD for perforated appendicitis by institutions participating in ACS NSQIP – Pediatric. Moreover, we believe that future reporting will benefit from redefining our wound classification system to reflect what we have learned about clinical variables and their impact on risk stratification.

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Abbreviations

PA	perforated appendicitis
EBD	evidence-based definition
ACS NSQIP	American College of Surgeons National Surgical Quality Improvement Project
PUF	Participant Use File

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Figure 1. Post-operative abscess rates by definition of perforated appendicitis

Each mark represents an individual published study reporting post-operative abscess rates following perforated appendicitis. The non-evidence based trials have a significantly higher amount of variation than the evidence-based trials.

Table 1
Studies evaluating post-operative abscess rates in pediatric patients with perforated appendicitis since 2008

Each row is identified by the lead author and the year each trial was published. The number of patients, number of abscesses, and rate of post-operative abscess formation are shown, along with the definition used to define perforation. The standard definition is a hole in the appendix or an intraabdominal fecalith. The trials that employed the evidence based definition (EBD) had a significantly higher post-operative abscess rate than those that did not.

Trials that did not employ evidence-based criteria				
Publication by first author (year)	# of patients	# of post-operative abscesses	Rate of post-operative abscess formation	Perforation criteria
Thambidorian (2008)	51	6	0.12	Perforation, gangrene, mass formation or intraabdominal abscess
Pham (2009)	72	3	0.041	Intraoperative picture of perforation or gangrene
Wang (2009)	128	10	0.082	Perforation or intraabdominal abscess
Sleem (2009)	246	32	0.013	None given
Sesia (2010)	43	6	0.14	None given
Lee (2011)	2231	167	0.075	None given
Lee (2011)	1855	276	0.149	None given
PUF data (2012)	1170	89	0.0761	None given
Naiditch (2012)	230	44	0.192	None given
Groves (2013)	289	19	0.066	Perforation, gross contamination, or abscess
Fallon (2013)	484	116	0.24	Gangrene or perforation
Fallon (2013)	50	14	0.28	Transmural necrosis, perforation, abscess cavity, or diffuse purulent fluid
Minutolo (2014)	230	11	0.048	Abscess, gangrene, or perforation
Thereaux (2014)	141	10	0.071	Gangrene with presence of purulent collections
Average			.1257	
Trials that employed evidence based criteria				
Publication by first author (year)	# of patients	# of post-operative abscesses	Rate of post-operative abscess formation	Perforation criteria
St. Peter (2008)	131	24	0.18	Evidence-based definition
Fraser (2010)	102	20	0.195	Evidence-based definition
Garey (2011)	220	42	0.19	Evidence-based definition
Blakely (2011)	64	12	0.19	Evidence-based definition
St. Peter (2012)	220	41	0.187	Evidence-based definition
Average			0.1884	