Journal of Pediatric Surgery 51 (2016) 1900–1903

Contents lists available at ScienceDirect

Journal of Pediatric Surgery

journal homepage: www.elsevier.com/locate/jpedsurg

Operative wound classification: an inaccurate measure of pediatric surgical morbidity☆,☆☆

Katherine W. Gonzalez, Brian G. Dalton, Brendan Kurtz, Michael C. Keirsey, Tolulope A. Oyetunji, Shawn D. St. Peter *

Department of Pediatric Surgery, Children's Mercy Hospital, Kansas City, MO

ARTICLE INFO

Article history:
Received 19 May 2016
Received in revised form 17 July 2016
Accepted 18 July 2016

Key words:
Wound classification
Pediatric
Laparoscopy
Complications
Infection

ABSTRACT

Background: Wound classification has catapulted to the forefront of surgical literature and quality care discussions. However, it has not been validated in laparoscopy or children. We analyzed pediatric infection rates based on wound classification and reviewed the most common noninfectious complications which could be a more appropriate measure for quality assessment.

Methods: We performed a retrospective review of 800 patients from 2011 to 2014 undergoing common procedures at a tertiary pediatric hospital. Demographics, procedure, wound classification and complications were analyzed using descriptive statistics.

Results: Infection rates were in the expected low range for clean procedures. However, 5% of pyloromyotomy patients required readmission and 10% of circumcision patients developed penile adhesions; 2% required reoperation. Ostomy reversal, a clean contaminated case, had 17% wound infections, whereas acute appendicitis, a contaminated case had only a 4% infection rate. Laparoscopic cholecystectomy (clean-contaminated or contaminated depending on inflammation) had 2% postoperative infections. Perforated appendicitis, a dirty procedure had an 18% infection rate, below the expected >27% for dirty cases in adults.

Conclusions: Current wound classifications do not accurately approximate the risk of surgical site infections in children, particularly for laparoscopic procedures. It would be more appropriate to grade hospitals based on disease and procedure specific complications.

Over the past decade, surgical wound classification has catapulted to the forefront of surgical literature and quality care discussions as a way to decrease the incidence, morbidity and cost of surgical site infections. Wound classification is divided into four categories: clean, clean contaminated, contaminated and dirty and is utilized by the Association of perioperative Registered Nurses (AORN) to classify all operative procedures [1]. These categories have been used to estimate surgical site infection rates in the adult population, 1%–5%, 3%–11%, 10%–17%, and >27% respectively. A recent review of the ACS-NSQIP database found significantly lower rates of both superficial and deep surgical site infections. In comparison to the previous estimates, superficial surgical site infections only occurred in 1.8% clean, 3.9% clean contaminated, 4.8% contaminated and 5.2% dirty cases. Organ space infections occurred in 0.3%, 1.9%, 2.6%, and 4.5% respectively [2]. After minimally invasive procedures, when SSI does occur, there is little or minimal associated morbidity and it most often does not require readmission or reoperation. In addition, the classification itself is often documented incorrectly. A recent review of pediatric appendectomies found that the documented wound classification was discordant with the diagnosis based wound classification in 92% of cases [3]. Despite these disparities the wound classification and resultant surgical site infection rates continue to be used to grade providers and hospital institutions, rather than highlighting rates of procedure specific complications which are likely to produce more important consequences.

The primary objective of this study was to evaluate the incidence of surgical site infections for common pediatric surgical procedures and correlate that with the intraoperative wound classification. The main hypothesis was that surgical site infections in children occur far less frequently than estimated percentages based on intraoperative wound classification. The secondary objective was to evaluate the

☆ Author Contributions: Katherine W. Gonzalez: Study design, acquisition of data, analysis and interpretation of data, drafting of manuscript, critical revision of manuscript Brian G. Dalton: Acquisition of data, analysis and interpretation of data, critical revision of manuscript Brendan Kurtz: Acquisition of data Michael C. Keirsey: Acquisition of data Tolulope A. Oyetunji: Study design, analysis and interpretation of data; critical revision of manuscript Shawn D. St. Peter: Study conception and design, analysis and interpretation of data, drafting of manuscript, critical revision of manuscript.

☆☆ This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

* Correspondence to: S. D. St. Peter, Children's Mercy Hospital, 2401 Gillham Road, Kansas City, MO 64108. Tel.: +1 816 983 6465; fax: +1 816 983 6885.
E-mail address: sspeter@cmh.edu (S.D. St. Peter).

http://dx.doi.org/10.1016/j.jpedsurg.2016.07.010
0022-3468/

noninfectious complications and their rates in order to identify important hazards not only for discussion in the operating room but also for quality assessment.

1. Methods

An institutional review board approved (#1490383) retrospective review was performed in 800 children undergoing 8 common operations. Patients younger than 18 years who underwent the following procedures between 2011 and 2014 were included: laparoscopic appendectomy for perforated appendicitis, laparoscopic appendectomy for nonperforated appendicitis, laparoscopic pyloromyotomy, laparoscopic cholecystectomy, open inguinal hernia repair, umbilical hernia repair, circumcision, and ostomy reversal. Each procedure was performed by one of 9 board certified pediatric surgeons at a dedicated tertiary children's hospital. One hundred patients were selected for each procedure beginning in 2014 and working retrospectively in consecutive order. Individual chart review was then performed and no missing data were encountered. Follow up period ranged from 6 months to 4 years based on the date of the original operation. Patients were excluded if the indication for the operation or associated procedures influenced the standard wound classification, perioperative antibiotics given, or extent of the operative intervention.

Data analyzed included demographics, procedure, operative time, wound classification, perioperative antibiotic use, American Society of Anesthesiologists (ASA) classification, infection rate and procedure specific complication such as anastomotic leak and hernia recurrence. Superficial surgical site infection was defined as purulent drainage at the incision, culture positive specimen, incision requiring open drainage, or physician diagnosis within 30 days of surgery. Organ space infection was categorized as infection below the fascia level confirmed with purulent drainage, imaging, and/or physician diagnosis within 30 days. Data were summarized using descriptive statistics and reported with percentages and median values (minimum, maximum).

2. Results

Eight hundred and forty eight patients were identified. Exclusions included: two patients undergoing interval laparoscopic appendectomies without active inflammation and a third with a Ladd's procedure; 34 patients with chordee and 5 patients with hypospadias undergoing circumcision, 5 patients who had a laparoscopic pullthrough procedure for Hirschsprung's disease in association with their colostomy reversal; and 1 who had a laparoscopic pullthrough procedure with their circumcision. Eight hundred patients were included for analysis. Demographics of the patient population are displayed in Table 1.

2.1. Clean

Clean procedures including open inguinal hernia repair, umbilical hernia repair, circumcision and laparoscopic pyloromyotomy had superficial infection rates of 0%, 1%, 2%, and 1% respectively (Table 2). One umbilical hernia recurred after 2.5 months and was repaired operatively. Ten percent of circumcision patients developed penile adhesions, and 2 of these patients required reoperation. Five percent of pyloromyotomy patients required readmission, 3 for persistent emesis, one for apnea and one for abnormal stooling. Twelve percent of clean cases were incorrectly classified. Between 5% and 11% of patients received preoperative antibiotics (Table 3).

2.2. Clean-contaminated

Ostomy reversal and laparoscopic cholecystectomy for symptomatic cholelithiasis and biliary colic both qualified as clean contaminated cases. Seventeen percent of ostomy reversal patients had a superficial infection and two cholecycstectomy patients developed a surgical site infection (one patient with biliary dyskinesia, a clean-contaminated case and one patient with cholecystitis, a contaminated case). Two ostomy reversal patients had an intestinal perforation and four developed an anastomotic leak. Three of the four patients with a leak were rediverted for free air and did not develop an abscess. The fourth presented with a colocutaneous fistula which then spontaneously closed. One patient had postoperative bleeding necessitating blood product transfusion. Six patients had operative exploration for bowel obstruction. Sixty-two percent of ostomy reversal patients and 10% of cholecystectomy patients (biliary colic and symptomatic cholelithiasis) had inaccurate intraoperative wound classification. Ninety seven and 96% of patients received preoperative antibiotics respectively.

2.3. Contaminated

Laparoscopic appendectomy for nonperforated appendicitis, a contaminated case, had 2% superficial and 2% organ space (intraabdominal abscess) infections. Laparoscopic cholecystectomy for acute cholecystitis, also contaminated, had one postoperative infection as above. One appendectomy patient was readmitted for small bowel obstruction requiring operative intervention. Three additional patients were readmitted with constipation and persistent pain. Two percent of nonperforated appendicitis patients had an incorrect wound classification. Sixty-five percent of cholecystectomy patients (contaminated) were inaccurately classified. Ninety-nine percent of appendectomy patients and 90% of cholecystectomy patients received preoperative antibiotics.

2.4. Dirty

Perforated appendicitis, classified as a dirty case, had 3% superficial and 15% organ space (intraabdominal abscess) infections for a total of 18%. Four patients with intraabdominal abscess were readmitted. Two additional patients were readmitted and had operative exploration for small bowel obstruction. Fourteen percent of patients had discordant wound classification. All received preoperative and postoperative antibiotics.

3. Discussion

The degree of wound contamination has been demonstrated to directly influence the rate of surgical site infection [4]. However,

Table 1
Demographics.

	Appendectomy (nonperforated)	Appendectomy (perforated)	Laparoscopic pyloromyotomy	Open inguinal hernia repair	Umbilical hernia repair	Cholecystectomy	Circumcision	Ostomy Reversal
Age (yr)	11.5 (2.1, 17.5)	9.4 (1,7, 17)	34d (18, 128d)	3.4 (0.2, 17.4)	4.7 (0.3, 16.7)	15 (0.1, 17.9)	1.4 (0, 16.4)	0.8 (0.1, 17.8)
Male (%)	59	65	79	95	45	31	100	58
Weight (kg)	44.1 (15, 100)	36.7 (12.5, 141)	3.9 (2.4, 6.9)	16.0 (4.7, 71.5)	18.1 (5.6, 71.7)	64.7 (3.1, 147.9)	10.6 (3.4,84.3)	8.3 (2.1, 84.6)
Height (m)	1.5 (1, 1.9)	1.4 (0.9, 1.9)	0.5 (0.2, 0.8)	1.0 (0.5, 1.7)	1.1 (0.5, 1.7)	1.6 (0.5, 1.9)	0.8 (0.5, 1.8)	0.7 (0.3, 1.8)
Isolation status (%)	0	1	0	2	2	0	3	2
Average ASA	2	2	2	1.5	1.4	2.1	1.6	3