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Pediatric Surgeon-Directed Wound Classification Improves Accuracy

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Abstract

Background—Surgical wound classification (SWC) communicates the degree of contamination in the surgical field and is used to stratify risk of surgical site infection and compare outcomes amongst centers. We hypothesized that changing from nurse-directed to surgeon-directed SWC during a structured operative debrief we will improve accuracy of documentation.

Methods—An IRB-approved retrospective chart review was performed. Two time periods were defined: initially, SWC was determined and recorded by the circulating nurse (Pre-Debrief 6/2012-5/2013) and allowing six months for adoption and education, we implemented a structured operative debriefing including surgeon-directed SWC (Post-Debrief 1/2014-8/2014). Accuracy of SWC was determined for four commonly performed Pediatric General Surgery operations: inguinal hernia repair (clean), gastrostomy +/- Nissen fundoplication (clean-contaminated), appendectomy without perforation (contaminated), and appendectomy with perforation (dirty).

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Results—183 cases Pre-Debrief and 142 cases Post-Debrief met inclusion criteria. No differences between time periods were noted in regards to patient demographics, ASA class, or case mix. Accuracy of wound classification improved Post-Debrief (42% vs. 58.5%, $p=0.003$). Pre-Debrief, 26.8% of cases were overestimated or underestimated by more than one wound class, vs. 3.5% of cases Post-Debrief ($p<0.001$). Interestingly, the majority of Post-Debrief contaminated cases were incorrectly classified as clean-contaminated.

Conclusions—Implementation of a structured operative debrief including surgeon-directed SWC improves the percentage of correctly classified wounds and decreases the degree of inaccuracy in incorrectly classified cases. However, following implementation of the debriefing, we still observed a 41.5% rate of incorrect documentation, most notably in contaminated cases, indicating further education and process improvement is needed.

Keywords

Surgical Wound Classification; Surgical Site Infection; Debrief; Checklist; Pediatric Surgery

1. BACKGROUND

Surgeons communicate the degree of intraoperative contamination in a detailed operative report and by assigning a surgical wound classification (SWC). SWC is a universal system established in 1964 that divides operative cases into one of four categories: clean, clean-contaminated, contaminated, or dirty/infected (Table 1)[1]. Although the process of documentation varies amongst institutions, SWC is typically recorded by either the circulating nurse, resident physician or surgeon based on his or her clinical decision-making. The literature demonstrates a clear correlation between surgical wound class and postoperative complications[1–5]. Traditionally, the rate of surgical site infections (SSI) by wound class has been documented as 1%–5% (clean), 3%–11% (clean/contaminated), 10%–17% (contaminated), and over 27% (dirty/infected)[1]. More recent data from the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) continues to support a relationship between increasing wound class and increasing rates of SSI; however, recent studies have shown lower SSI rates across the wound classes[6]. Given the consistent correlation between SWC and outcomes, researchers, hospitals, quality improvement organizations, and third party payers often use SWC as a method of risk stratification for SSI and postoperative complications[7–9]. Despite this fact, the current literature demonstrates significant inaccuracies in the reporting of wound classification, especially in pediatric cases[1,10,11].

To date, little data exists on interventions to improve the accuracy of reporting SWC. Because the operative surgeon has primary knowledge of the conditions and degree of bacterial contamination in the operative field and there is ample literature demonstrating the utility of checklists in decreasing errors, we hypothesized that by changing from a nurse-directed to a surgeon-directed surgical wound classification system through implementation of a structured operative debriefing summarizing the important operative findings, including wound class, we would improve accuracy of documentation. We show here that implementation of a structured operative debrief, including surgeon-directed SWC, improved the percentage of correctly classified wounds for common pediatric surgical

procedures. Additionally, for those cases that remained incorrectly classified, the degree of inaccuracy was decreased.

2. METHODS

2.1 Subjects

The pre and post intervention patients were children under the age of 18 undergoing common pediatric surgery procedures. The following procedures were chosen in order to represent each surgical wound class: inguinal hernia repair (clean), gastrostomy tube placement with or without Nissen fundoplication (clean-contaminated), appendectomy without perforation (contaminated), and appendectomy with perforation (dirty/Infected). All operations were performed by a small group (n=4) of General Pediatric Surgeons.

2.2 Intervention

A formal surgeon-directed debriefing, modeled after World Health Organization recommendations[12], was instituted at the completion of each operative case prior to closure of skin (Table 2). This debriefing included clarification of correct counts and specimens, operation completed, pre-operative antibiotic administration and re-dosing, surgeon concerns, anesthesia concerns, patient disposition, and SWC. Completion of the debriefing process was then documented in the anesthesia record by the anesthesia resident, CRNA, or attending. The surgical wound class was recorded in the medical record by the surgical resident assistant after completion of the surgery.

Prior to instituting the structured debriefing, the surgeons and anesthesiologists were educated about the process during two consecutive monthly meetings of the operating room physician staff as well as through emailed informational handouts. The operating room nursing staff were educated during two consecutive monthly meetings of the operating room staff. Monthly reminders about the structured debriefing were provided to physicians and nurses by members of the operating room efficiency committee during these respective meetings.

For the study, all operative reports were examined in detail by the authors to assess if an unexpected intraoperative complication or finding would alter the expected wound class. For example, if an operative report documented a normal appearing appendix with no acute inflammation in a case of suspected acute appendicitis, the expected wound class for this study was determined to be clean-contaminated rather than contaminated.

2.3 Study Design

Following Institutional Review Board approval, a retrospective chart review was completed from June 2012 to August 2014. Patients were identified using surgical CPT codes for inguinal hernia repair, gastrostomy tube placement with or without Nissen fundoplication, and appendectomy with or without perforation. Two time periods were identified. During the first time period, from 6/2012 to 5/2013, the surgical wound class was determined and recorded by the circulating nurse based on their professional judgment, typically without direct surgeon input (Pre-Debrief). In the second time period, from 1/2014 to 8/2014, the

new debriefing system was employed and the SWC was determined by the attending pediatric surgeon and recorded by the surgical resident (Post-Debrief). A total of 350 cases were identified for analysis in the 6/2012 to 5/2013 and 1/2014 to 8/2014 time periods. After review, 25 cases excluded for one of the following reasons: the case had no documentation of wound class, the case had no documentation of a debriefing after the implementation date, and the case involved one of the aforementioned procedures as a component of a more complex operation (for example appendectomy during Ladd's procedure for malrotation). Of the 325 cases that were analyzed, 183 cases were reviewed in the time period Pre-Debriefing and 142 cases were reviewed in the Post-Debriefing time period. The distribution of study patients is illustrated in Figure 1.

All operative notes for the 325 cases were reviewed by a surgical resident and assigned the correct wound class based on the definitions outlined in Table 1. If there was any uncertainty regarding correct wound classification based on the operative note findings, the note was reviewed by two board certified pediatric surgeons to determine correct classification.

2.4 Primary and Secondary Outcomes

Our primary outcome was the accuracy of the wound classification during the two time periods. Our secondary outcomes were degree of error in wound classification and frequency of surgical complications in each wound class. In order to determine degree of error, all cases were reviewed and the incorrectly documented cases identified. Each case was given a numerical value for whether the degree of bacterial contamination was overestimated (positive) or underestimated (negative). For example, if a clean case was overestimated and documented as a contaminated case, it received a numerical value of +2. Likewise, if a dirty/infected case was underestimated as a contaminated case, it received a numerical value of -1.

F-tests were performed to evaluate the data confounding factors, including frequency of operation, age and gender of patient, assigned wound class, operative time, and preoperative ASA classification. Where significant, comparisons were made between the Pre-Debrief and Post-Debrief period using χ^2 analysis. Finally, patient outcomes were analyzed by calculating the overall rates of surgical site infections, readmissions and total complications in each wound class group.

2.5 Statistics

Statistical analysis was performed using SPSS software with one-way ANOVA and Chi squared analysis where *p* value of less than 0.05 was considered statistically significant.

3. RESULTS

Surgical wound class was evaluated in 325 cases. A total of 83 hernia cases, 73 gastrostomy tube cases, 121 appendectomies without perforation and 47 appendectomies with perforation were included in the analysis.

Following implementation of a formal debriefing and surgeon-directed wound classification, we observed an overall increase in the number of cases with correct SWC documentation

from 42% to 58.5% (p value = 0.003). Improvement was seen across all wound classes as depicted in figure 2. The accuracy of clean case documentation improved from 89.8% to 94.4%, clean-contaminated case documentation improved from 53.2% to 86.8%, contaminated case documentation improved from 3.3% to 8.3%, and dirty/infected case documentation improved from 18.5% to 60%. The majority of contaminated cases were still incorrectly identified as clean-contaminated. Even after our intervention, 91.7% of appendectomies without perforation had inaccurate wound classification (83.3% were documented as clean-contaminated).

We also observed an improvement in the degree of error after implementation of a formal debriefing. Prior to the institution of the surgeon-directed wound classification system, the degree of bacterial contamination was either overestimated or underestimated by more than one wound class in 26.8% of cases compared to 3.5% of cases after the institution of our physician directed wound classification ($p < 0.001$, Figure 3). The percentage of cases overestimated or underestimated by more than one wound class decreased from 55% to 6.3% in contaminated cases and from 59.2% to 10% in dirty/infected cases. In the clean and clean-contaminated cases, there were no instances where the degree of error was greater than one wound class.

Next, the data was evaluated for any confounding factors (Table 3). In the Pre- and Post-Debrief periods, we compared the numbers of each operation performed, the numbers of each wound classification assigned on review, the ASA class of patients, the average OR time, and the age of the patients. An assessment of the data showed the following factors had a statistically significant impact on whether the wound class was properly identified: type of operation, wound classification and patient age. As a result, the two datasets were analyzed and these factors were found to be equally represented in both groups.

Finally, our data was analyzed to determine if a relationship existed between wound classification and surgical outcomes across all 325 cases. Three main endpoints were identified: superficial surgical site infection (SSI), readmission rate and overall surgical complication rate. The rate of SSI was found to be highest in the clean-contaminated cases (6%). Surprisingly, the surgical site infection rate was lower in the contaminated (0%) and dirty/infected (2%) cases, however this is likely due to a limited sample size. There was a statistically significant difference between the rates of SSI in each of the 4 wound classifications ($p=0.022$). The rate of readmission was substantially higher for the contaminated and dirty/infected cases (64.3% of all readmissions) than the clean and clean-contaminated groups (35.7% of all readmissions) ($p=0.001$). Finally, the majority of postoperative complications in our study population ($n=30$ complications) were in the dirty/infected cases (60% of all complications). The complication rate for the individual wound classes were 1% for clean cases, 9% for clean-contaminated cases, 3% for contaminated cases, and 38% in dirty/infected cases (p value of <0.001). The most common postoperative complications were identified. In our study group, we found 15 episodes of postoperative abscess formation, followed by 4 episodes of wound infection, 3 episodes of wound dehiscence, and 2 episodes of *Clostridium difficile* colitis.

4. DISCUSSION

Overall, this study supports our original hypothesis by showing improvement in the accuracy of wound classification and reduction in the degree of error in incorrectly documented cases after implementation of a surgeon directed wound classification system. Overall, the cases with correct documentation of SWC increased from 42% to 58.5%. We documented even more dramatic improvements in the clean-contaminated cases (53.2% to 86.8%) and dirty/infected cases (18.5% to 60%). Furthermore, of those cases with incorrect documentation of SWC, our degree of error was substantially decreased from 26.8% of cases compared to 3.5% of cases after the institution of our physician directed wound classification. Despite still demonstrating a large percentage of incorrectly documented contaminated cases, our intervention was able to decrease the degree of error by more than one wound class in that group from 55% to 6.3%.

Correct identification of SWC is essential for hospitals, quality improvement committees, and third party payers to risk stratify and establish benchmarks for surgical outcomes. Unfortunately, multiple studies continue to show a failure in our ability to accurately document SWC. Levy et al conducted a multicenter evaluation of 2,034 pediatric surgery cases at 11 institutions and found overall SWC concordance of 56%, ranging from 47% to 66% across institutions[6]. The authors concluded that if SWC is to continue to be used for quality benchmarks, institutions must develop processes to ensure increased accuracy and reliability. Our study supports their argument by demonstrating a persistent problem in pediatric surgery of misidentifying patient SWC and therefore postoperative risk stratification. Of note, our study examined only the accuracy of documentation in four very common and relatively straightforward surgical procedures. It is unknown if documentation accuracy would worsen when complex, rare cases are examined.

Although our intervention increased the overall accuracy of documentation, our institution still has significant room for improvement given our current correctly documented case rate of only 58.5%. This fact was even more evident in our non-perforated appendectomy cases where we noted only 8.3% correct documentation even after our intervention. The vast majority of these cases were documented as clean contaminated. Although many surgeons have classically assigned a clean contaminated wound class to uncomplicated appendicitis, this is technically incorrect. In cases where inflamed bowel is divided (as in the case of an uncomplicated appendicitis), the wound class should be documented as contaminated. If the operative findings indicate a normal appearing appendix without erythema, edema or evidence of inflammation was found or in cases of interval appendectomy where the appendix is no longer inflamed, the wound class is clean contaminated. We had 9 cases in which there was no evidence of inflammation and a correct wound classification for this group was based on clean contaminated wound class. A 1993 study by Cardo et al demonstrated an 88% accuracy in wound classification after the implementation of a month long circulating nurse education and training session[13]. Although this study is limited by its sample size of only 100 cases (with only 50 general surgery cases), it illustrates the importance of formal education modules and interdisciplinary cooperation when implementing a quality improvement strategy. A potential future intervention would be to

implement a formal debriefing and a resident surgeon educational module with reference guide in the electronic medical record.

During data analysis, we also noted that the correct wound class for some cases was explicitly documented in the attending operative note but still recorded incorrectly by the resident. This anomaly may be related to the resident being distracted during the debriefing by sponge counts or closing. In addition, resident documentation of wound class is often done outside the operating room in recovery after the attending is no longer immediately available for clarification. As a result, we could eliminate this error by a formal read back mechanism in which the attending's SWC determination is verified and documented in real time before leaving the operating room.

It is difficult to draw conclusions about postoperative outcomes from our data given that we documented a total of only 30 complications in our dataset. This is most likely secondary to the fact our representative pediatric cases for each wound class are generally considered routine low risk surgical procedures in this patient population. Surprisingly, unlike the work of Ortega et al, we do not document progressively higher rates of surgical site infections from clean to dirty wounds[14]. Instead, our data showed the highest rate of superficial wound infections in the clean-contaminated patients. There are many possible rationales for this discrepancy. The selected clean-contaminated procedure was a gastrostomy tube placement. These tubes are often subject to local trauma from pulling/tugging and contamination from developmentally delayed children. As a result, erythema around the tube from trauma or local excoriation from feedings or gastric leakage may have been documented incorrectly as a SSI. Furthermore, in all 325 cases, we documented a total of only 6 postoperative SSI. As a result, it is difficult to accurately form conclusions given our low power. Of note, all 6 patients who developed SSI did receive appropriate preoperative antibiotics. Finally, by evaluating laparoscopic appendectomies as our representative case for contaminated and dirty/infected procedures, we would expect a lower rate of SSI than open cases in the same wound class[15]. Only one of our appendectomy cases and three gastrostomy tube cases were converted to open. Our data goes beyond the current literature and also addresses the frequency of readmissions and overall complications by wound class. Although our rates of readmission and overall complications remain low ($n=14$ and $n=30$, respectively), there is an obvious increase in these adverse outcomes in the dirty/infected wound class.

There are limitations to our study. When we implemented this intervention, in the first few months of the post-debriefing period, there was not an automatic prompt in our electronic medical record for recording of the SWC. The automatic electronic medical record prompt started in January 2014, so we have analyzed this period as our Post-Debrief period. It is possible that the adoption rate and accuracy prior to this electronic reporting was poor. Another limitation is our evaluation of confounding variables. We attempted to correct for this by evaluating the data fields that we collected (age, gender, operative time, etc.). However, there are other variables that we did not collect in our analysis or factors influencing accuracy of SWC that may contribute to a residual confounding effect. Additionally, in the cases where SWC was incorrectly recorded during the post-debriefing era, we are unable to extract who was responsible for the inaccurate documentation from the

electronic medical records. At our institution, the majority of cases are done with general surgery residents, but multiple other specialties rotate on the pediatric surgery team. As a result, anesthesia, ENT, and urology residents may participate as the assisting resident surgeon in some operative procedures. These residents may not have similar training in assessing SWC or knowledge of the operative anatomy. An analysis of this data might help determine the providers to focus quality improvement measures towards as we contemplate future interventions.

5. CONCLUSIONS

Surgical wound classification is an effective postoperative method of communicating the degree of bacterial contamination in the surgical field and risk stratifying patients for potential postoperative complications. Unfortunately, this method is only as useful as the accuracy of the recorded data. Given that surgeons have the most knowledge of the intraoperative surgical findings and are ultimately responsible for postoperative complications, it is their responsibility to document correct SWC. Overall, our intervention has improved SWC accuracy for common pediatric procedures by a surgeon directed classification system, and decreased the degree of error in incorrectly classified cases. However, significant challenges and opportunities for ongoing process improvement remain, particularly for contaminated cases.

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Figure 1. Study Design

Distribution of the patients identified, those excluded, and those included in each study arm.

Figure 2. Accuracy of Wound Classification Increased Post-Debrief

183 cases Pre-Debrief and 142 cases Post-Debrief met inclusion criteria. No differences between groups were noted in patient demographics, ASA class, or case mix. Accuracy of wound classification increased after implementation of surgeon directed wound class overall (42% vs. 58.5%, $p=0.003$) as well as across all individual wound classes. We documented more dramatic improvements in the clean-contaminated cases (53.2% to 86.8%) and dirty/infected cases (18.5% to 60%).

Figure 3. Degree of Over/Underestimation of Surgical Wound Class

Pre-Debrief, 26.8% of cases were overestimated or underestimated by more than one wound class vs. 3.5% of cases Post-Debrief ($p < 0.001$).

Figure 4. Degree of Over/Underestimation of SWC by Wound Class

(A) Post-debrief, there were no instances where the degree of error was greater than one wound class in clean or (B) clean-contaminated cases. (C) The percentage of cases overestimated or underestimated by more than one wound class decreased from 55% to 6.3% in contaminated cases. (D) The percentage of cases overestimated or underestimated by more than one wound class decreased from 59.2% to 10% in dirty/infected cases.

Table 1
Surgical Wound Classification

Surgical Wound Classification Guide from the University of Wisconsin Hospital and Clinics UWHC Infection Control Department.

Wound Class	Definition
Class I (Clean)	An uninfected operative wound in which no inflammation is encountered and the respiratory, alimentary, genital, or uninfected urinary tract is not entered. In addition, clean wounds are primarily closed and, if necessary, drained with closed drainage. Operative incisional wounds that follow non-penetrating (blunt) trauma should be included in this category if they meet the criteria.
Class II (Clean-Contaminated)	An operative wound in which the respiratory, alimentary, genital or urinary tracts are entered under controlled conditions and without unusual contamination. Specifically, operations involving the biliary tract, appendix, vagina, and oropharynx are included in this category, provided no evidence of infection or major break in technique is encountered.
Class III (Contaminated)	Open, fresh, accidental wounds. In addition, operations with major breaks in sterile technique (e.g., open cardiac massage) or gross spillage from the GI tract, and incisions in which acute, non-purulent inflammation is encountered are included in this category.
Class IV (Dirty/Infected)	Old traumatic wounds with retained devitalized tissue and those that involve existing clinical infection or perforated viscera. This definition suggests that the organisms causing post-operative infection were present in the operative field before the operation.

Table 2
Components of the Postoperative Surgical Debriefing

Our intervention consisted of a structured postoperative surgical debriefing which was lead by the attending surgeon and recorded in the electronic medical record by the anesthesia team as a review of key aspects of the case including surgery performed, antibiotic dosing, surgeon and anesthesia concerns, patient disposition, and surgical wound class.

Components of Structured Surgical Postoperative Debriefing
<ul style="list-style-type: none">• Correct sponge and instrument counts• Correct specimen labeling• Patient name, indication for surgery and surgery performed• Preoperative Antibiotics and Antibiotic Re-dosing• Anesthesia concerns• Surgical concerns• Patient disposition (Home, General care Floor, IMC, ICU)• Surgical wound class

Table 3
Evaluation of Potential Confounding Factors

No differences between time periods were noted in regards to patient demographics, ASA class, or case mix.

Confounding Factor	Pre-Debrief	Post-Debrief	P value
Operation (n)			
Appy w/perf	27	20	0.917
Appy w/o perf	67	49	
Gastrostomy	38	35	
Hernia	47	36	
Interval Appy	3	2	
Nissen fundoplication	1	0	
Wound Class (n)	49	6	0.986
Clean	47	38	
Clean-contaminated	60	48	
Contaminated	27	20	
Dirty or Infected			
ASA (n)	76	40	0.085
1	74	68	
2	30	32	
3	3	2	
4			
	106.78 ± 56.1	104.46 ± 46.27.78 ±	0.691
OR time (min)	7.02 ± 5.99	5.58	0.253
Age (yrs)			

Table 4**Rates of SSI, Readmission and Complications by SWC**

We documented only 30 total complications of any kind. The rate of wound infections was found to be highest in the clean-contaminated cases. The rate of readmission was substantially higher for the contaminated and dirty/infected cases (64.3% of all readmission documented in our study) than the clean and clean-contaminated groups (35.7% of all readmissions documented in our study) (p value 0.001). The overall rate of postoperative complication was found to be highest in the dirty/infected cases as compared to the other wound classes (p value of <0.001).

Complication	Clean N=85	Clean-contaminated N=85	Contaminated N=108	Dirty/Infected N=47	P value
SSI	0 (0%)	5 (6%)	0 (0%)	1 (2%)	0.022
Readmission	1 (1%)	4 (5%)	2 (2%)	7 (15%)	0.001
All Complications	1 (1%)	8 (9%)	3 (3%)	18 (38%)	<0.001