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ORIGINAL ARTICLE

Pediatric surgical site infection in the developing world: a Kenyan experience

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Abstract

Background The purpose of the current study was to determine the incidence of pediatric surgical site infections (SSIs) at an academic children's hospital in rural sub-Saharan Africa and to identify potentially modifiable risk factors.

Methods Prospectively collected data from 1,008 surgical admissions to BethanyKids Kijabe Hospital (Kijabe, Kenya) were analyzed retrospectively. Follow-up data were available in 940 subjects.

Results SSIs occurred in 6.8% of included subjects ($N = 64$). Superficial (69%) and deep (29%) infections of the back (38%) and head (25%) were most common. When comparing children who developed SSI to those who did not, we found that wound contamination classification and duration of operation were the only variables with significant differences between groups.

Conclusions Our rate of SSI among pediatric patients in sub-Saharan Africa is the lowest reported in the literature to date. More work is needed to identify modifiable risk factors for pediatric SSI in low- and middle-income countries.

Keywords Surgical site infection · Rural surgery · Developing world

Introduction

While pediatric surgical site infections (SSIs) are increasingly rare in wealthy nations, they continue to be a major cause of morbidity and mortality in low- and middle-income countries (LMICs) [1–3]. Studies addressing this problem are sparse and geographically sporadic, and very little is known about the actual incidence of health-care-related infections among children in areas of the world such as Africa. This dearth of information is an impediment to the design and implementation of effective interventions to prevent SSIs among the most vulnerable children around the world. We therefore undertook the current study to determine the incidence of pediatric SSIs at our institution, an academic pediatric surgical center in rural Kenya, and to identify potentially modifiable risk factors for pediatric SSI relevant to LMICs.

Methods

Study design

Prospectively collected data for all children (age <18 years) who underwent operation at our institution between January and November 2007 were analyzed retrospectively. These data were collected as part of a cluster-randomized cross-over trial (NCT00987402) evaluating surgeon hand scrubbing techniques (soap vs. alcohol rub) that has been published elsewhere [4]. Institutional ethics committee approval was obtained for this study, as were written consents for all included patients.

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Setting

Bethany Kids Kijabe Hospital is a 68-bed pediatric surgical unit within the AIC Kijabe Hospital, a 240-bed charitable general hospital in Kijabe, Kenya.

Subject inclusion and exclusion

All patients under the age of 18 years who underwent any operation at our hospital during the study period were assessed for inclusion in the study. Children undergoing re-operation (within 2 weeks of another surgical intervention) and children with operations classified as dirty were excluded from enrollment in the study.

Variables and outcomes measured

SSIs were diagnosed according to the modified US Centers for Disease Control and Prevention (CDC) definitions for nosocomial infection and were classified according to anatomical location (abdomen, groin, head, etc.) and depth (superficial incisional, deep incisional, or organ/space) [5].

Potential SSIs were documented by a trained staff nurse, and final diagnosis was by consensus among the study collaborators. Patients were surveyed for signs of SSI on ward rounds 3–4 days per week, and patients discharged prior to completion of data collection were reviewed in the outpatient clinic or contacted by telephone. The follow-up period was defined as 30 days after the initial operation (or 1 year if surgical implants were used). Routine microbiological investigation of causative organisms was not performed as part of the study.

Major analyzed variables included patient demographics (age and gender), admission type, operative procedure, surgical specialty, American Society of Anesthesiologists (ASA) patient risk classification, surgical site contamination classification, and duration of operation.

Data analysis

Statistical tests of significance included ANOVA and Student's t test for normal variables (reporting mean $\pm$ standard error of the mean) and Mann–Whitney U test for non-normal variables, including age and duration of operation (reporting median and interquartile range). One-sample Kolmogorov–Smirnov tests were used to determine variable normality. Categorical data were analyzed using Pearson's Chi-square or Fisher's exact test (with frequencies <5 for any included variable). All data were collected in Microsoft Access®, and analyses were performed using IBM SPSS Statistics® software.

Results

A total of 1,008 children were enrolled in the study. Of those, valid SSI data with adequate follow-up were available for 940 children (93% of enrolled subjects). SSIs occurred in 64 children (6.8%) and included 45 superficial (69%), 19 deep (29%), and one organ/space (1.5%) infection. The most common sites of SSI were the back (38%) and head (25%), followed by the abdomen, groin, and limbs (12.5% each). SSIs were diagnosed on post-operative day 17 $\pm$ 1.8 days (range 5–60 days).

Patient characteristics

The study included 382 girls and 558 boys (59%) with a median age of 1.2 $\pm$ 4.8 years (range 0–18 years). When comparing children who developed SSI with those who did not, we found no significant differences in median age ($P = 0.17$) or gender ($P = 0.99$). The majority of the patients had an ASA classification of either 1 (41%) or 2 (55%). Four percent of patients were ASA class 3 and one patient was ASA class 4. SSI rates were 6, 7.6, 2.9, and 100% for ASA classes 1, 2, 3, and 4, respectively ($\eta = 0.13$).

Operative characteristics

Operations were categorized as neurosurgical (63%), general (14%), orthopedic (9%), urological (8%), plastic (5.3%), and gynecological (1%). SSIs occurred most commonly in general surgery cases (11.6%), followed by neurosurgical (7%) and plastic surgery (6%) cases. Urological, orthopedic, and gynecological procedures had the lowest rates of SSI (3.8, 3.7, and 0%, respectively). However, these differences failed to reach statistical significance (χ^2 $P = 0.15$).

There were 887 elective operations (94%) and 53 emergency operations, with no significant difference in the rate of SSI between groups (6.4 vs. 13%, respectively, χ^2 $P = 0.12$). Likewise, there was no significant difference in the rates of SSI on comparing patients who had inpatient versus outpatient operations (6.8 vs. 8.3%, Fisher's exact $P = 0.58$) or those who had general endotracheal anesthesia versus conscious sedation (6.6 vs. 8.3%, χ^2 $P = 0.47$).

The median duration of operation was 50 $\pm$ 45 min. For patients who did not develop SSI, the median duration of operation was 50 $\pm$ 46 compared with 78 $\pm$ 60 min for those who did develop SSI ($P = 0.007$).

Contamination and antibiotics

Surgical sites were classified as clean in 66%, as clean-contaminated in 16%, and as contaminated in 18% of

Table 1 Linear regression analysis of risk factors for surgical site infection

	Standardized β-coefficient	P value
Age	−0.04	0.34
Gender	−0.003	0.93
Admission type[a]	−0.005	0.89
Urgency of operation[b]	−0.61	0.12
Wound contamination	0.13	0.001*
Anesthesia type	−0.04	0.34
Surgical specialty	−0.034	0.38
Duration of operation	0.09	0.03*
Antibiotic prophylaxis	0.27	0.51

* Significance set on $P < 0.05$

[a] Inpatient versus outpatient

[b] Emergent versus elective

cases. SSI occurred in 4.4% of clean cases, 6.2% of clean-contaminated cases, and 17% of contaminated cases. (χ^2 $P < 0.001$). Peri-operative antibiotics were used in 85% of clean cases, 93% of clean-contaminated cases, and 99% of contaminated cases, at the operating surgeon's discretion (χ^2 $P < 0.0001$). SSI occurred in 8% of cases in which antibiotics were used compared with 4% of cases in which antibiotics were not used (χ^2 $P = 0.19$) No significant association of prophylactic antibiotic use and SSI was found when comparing within surgical site contamination groups.

Multivariate analysis

Linear regression of potential risk factors for SSI showed only surgical site contamination and duration of operation to be associated with a significant difference in rates of SSI. However, these variables were not strong predictors of SSI (contamination $\beta = 0.13$, $P = 0.001$; duration $\beta = 0.09$, $P = 0.03$) (see Table 1).

Discussion

Recent advances in peri-operative patient care have made SSIs rare, particularly in the USA and other high-income nations [1, 6, 7]. However, several reports suggest that SSIs occur much more commonly in developing nations, where prolonged hospitalization, higher treatment costs, and the potential long-term disability that characterize SSI pose a critical threat to the fragile economic and social conditions of many individuals and communities [3, 4, 8–11]. A recent meta-analysis confirms that SSIs are the most prevalent cause of health-care-associated infections in LMICs and that rates are more than twofold greater in developing countries than in European nations or the USA [3].

One obstacle to preventative interventions in the developing world is a lack of epidemiological data, and this problem is especially pronounced in the field of pediatric surgery, where very little is known about the incidence of SSI or about what factors may contribute to its prevalence. We have, therefore, undertaken this study to critically evaluate the incidence and putative risk factors for SSI among children at our institution in rural Kenya.

The African perspective

The incidence of pediatric SSI in LMICs ranges from 5 to 25%, varying widely by region [2, 12–14]. To our knowledge, there are only two studies that have documented rates of pediatric SSI in sub-Saharan Africa [2, 14]. In comparison to these studies, as well as to studies among adult surgical patients in sub-Saharan Africa, we have demonstrated significant improvement in SSI prevention, with an overall infection rate of 6.8% across all specialties and incision classes.

Reporting on their pediatric general surgery experience in Nigeria, Ameh and colleagues found that their patients developed SSIs in 24% of cases [2]. It should be noted, however, that the majority of patients included in their study had contaminated incisions, which presumably skewed their findings. Wound contamination is an authenticated risk for SSI, and our study simply adds to the wealth of literature which has documented wound contamination classification as an independent predisposing factor for SSI [15, 16].

Recently, Mwachaka and colleagues analyzed their experience with ventriculoperitoneal shunts at a large, referral hospital in Nairobi, Kenya [14]. In this study, they reported an SSI rate of 19.7% in clean cases. The factors that led to our comparatively low rate of SSI in clean cases (4.4%) are not immediately clear. One possible explanation is our institution-wide protocol for the routine use of peri-operative prophylactic antibiotics, which led to high rates of administration of antibiotics, even in clean cases.

Data regarding the implementation of peri-operative antibiotics in hospitals in LMICs are limited, and, to our knowledge, there are no trials that have focused specifically on the effect of prophylactic antibiotics in this setting. A pilot study conducted in eight hospitals participating in the World Health Organization Safe Surgery Saves Lives Challenge suggests that overall morbidity and mortality is improved with the implementation of a pre-operative checklist that includes confirmation of appropriate antibiotic choice and timing, with the rate of SSIs in participant hospitals falling from 6.2 to 3.4% [17, 18]. None of the developing world hospitals included in the study had peri-operative antibiotic guidelines in place, nor did they routinely use peri-operative antibiotics prior to implementation of the checklist. These data lend credence to our belief that protocol-driven use of peri-operative antibiotics mitigates the burden of SSI at our hospital and that all developing world hospitals should implement standardized prophylactic antibiotic protocols as recommended by the Center for Disease Control and the WHO [17, 19–25].

The global perspective

Although the SSI rates we have achieved compare very favorably to other African institutions, it should be remembered that great disparities exist between the low-income and high-income nations.

In a retrospective database study of surgical patients from four American children's hospitals, an overall surgical site infection rate of 1.3% was reported with equal distribution across surgical specialties [1]. Likewise, in a retrospective, case–control study restricted to clean and clean-contaminated cases, Bucher and colleagues found that <1% of children developed SSIs at the St. Louis Children's Hospital during a 12-year period [26]. They also identified several risk factors for surgical site infection in their patient population. Among these was the duration of operation, which was an independent risk factor for SSI in our study and has been described as such by others [2, 27, 28]. The authors did not include the duration of operation in the logistic regression analysis, but they did report that patients who required ICU admission after operation were more likely to develop SSIs. Most likely, both of these factors are actually surrogates for complexity of surgical disease and comorbidities, although SSI may be increased by intra-operative hypothermia resulting from increased duration of surgery [29].

It is also interesting to note that Bucher and colleagues discovered a racial predisposition to SSI among children [26]. In their study, children of African descent were more likely to develop SSI. The authors speculated that there may be socioeconomic factors contributing to this unexpected finding. Indeed, the obvious but ill-defined disadvantages of poverty and illiteracy are putative contributors to complications, including SSI, among pediatric patients throughout the world.

Study effects and limitations

The current study has led to several beneficial effects in our institution, in the form of measures to counteract both the resource restrictions of our hospital as well as the educational and economical disadvantages our patients face. For example, since the completion of this study, we have instituted an Infection Prevention Control (IPC) Committee for the hospital that oversees all infection prevention related measures. Among other projects, this committee has spearheaded the installation of alcohol-based, hand-rub antiseptic dispensers throughout the hospital, and they regularly educate the hospital staff on the importance of provider hand hygiene to patient care.

There has also been renewed interest in patient hygiene as a factor in SSI. Our hospital has a long-standing but inconsistently implemented protocol for bathing hospitalized children the night before and the morning of any surgical procedure, with hospitalized patients receiving freshly washed gowns and linens. Because parents typically share beds with their hospitalized children, we also require that parents use clean gowns while in the hospital. The impact of pre-operative skin disinfection by bathing has been described in the literature, but no studies of its feasibility or effectiveness have been attempted in a resource-poor setting such as ours [30]. Nonetheless, we have redoubled our efforts at improving patient hygiene prior to elective operations.

Addressing disparities such as education, nutrition, and hygiene is undoubtedly an essential part of the global SSI prevention project. Likewise, investigators should consider other regionally defined risks for SSI, such as human immune deficiency virus and the acquired immune deficiency syndrome (HIV/AIDS), which are known to predispose patients to post-operative infectious complications, including SSIs [31]. Clinical and academic resources should be directed at addressing these issues.

Conclusion

We conclude that surgical site infection remains a significant cause of morbidity among pediatric surgical patients in the developing world and that modifiable risk factors of SSI in these children remain poorly defined. While great advances have been made in the peri-operative care of children in high-income countries, major research and clinical initiatives are needed to address the basic surgical needs of children throughout low- and middle-income countries.

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