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Major Article

An integrative care bundle to prevent surgical site infections among surgical hip patients: A retrospective cohort study

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Background: Surgical site infections (SSIs) following hip fracture surgeries have profound clinical and economic implications. The study aims to analyze the effect of an integrative SSI prevention care bundle on the SSI incidence among surgical hip patients. The study also aims to examine the association between SSI and mortality, readmission, duration of hospitalization, and hospital cost.

Methods: A retrospective cohort study was carried out to assess the incidence of SSI in an acute hip unit in Singapore from January 2015 to September 2017. Patients who developed SSI fell into the exposure group, whereas patients without SSI fell into the nonexposure group. A comparison of the incidence of mortality, readmission, length of stay, and inpatient bill size was conducted between the 2 groups.

Results: Among 758 hip surgeries performed during the study period, 14 (1.8%) SSIs were documented. Compared with patients with no SSI, patients with SSI were 4.27 times more likely to be readmitted within 30 days, had 2.47 times longer length of stay, and 2.15 times the inpatient bill size.

Conclusions: An integrative care bundle that capitalizes on the expertise of a multidisciplinary team has promoted shared responsibility and proven to be effective in preventing SSIs while contributing to better patient outcomes within the unit.

BACKGROUND

Surgical site infection (SSI) following hip fracture surgery is an unintended and often preventable complication with huge implications for both the patient and the health care system. A recent systematic review reported that patients with SSIs required extended hospitalization stay, as well as higher readmission and mortality rates imposing severe demands on health care resources.[1] Treating SSI is costly. Patients with SSI will require longer hospitalization for additional diagnostic tests and therapeutic treatment to be carried out, which eventually translates into a larger inpatient bill size. Consequently, SSIs constitute a substantial financial burden for both patients and the health care system.[1] Given the profound clinical and economic impacts of SSIs on patients and the health care system, efforts should naturally be directed toward its prevention.

SSI prevention is a fundamental principle of perioperative care for hip fracture patients and is one of the core safety efforts in the hip fracture unit (HFU) that was set up in our hospital in November 2014. Prevention of SSIs is complex and necessitates the integration of a range of measures before, during, and after surgical intervention. The care bundle was developed based on an extensive review of the literature, along with the expert opinions of a multidisciplinary team consisting of geriatricians, orthopedic surgeons, anesthetists, infectious disease physicians, nurses, and allied health professionals, with a collective experience of more than 100 years in the field. Risk factors were identified to aid in the establishment of perioperative strategies targeted at reducing the risk of SSI.[2,3] The HFU team aimed to optimize evidence-based processes of care by capitalizing on the expertise of various health care professionals.

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The literature on integrated care in acute hip fracture service appears to be largely clinician centered with the involvement of various medical disciplines beyond the orthopedics department. To our knowledge, there appears to be limited involvement of allied health professionals in this endeavor. The study embraces the essence of integrated care by involving not only the medical fraternity but also the nursing and allied health disciplines as stakeholders in the design and implementation of the SSI prevention care bundle.

Despite advancement in surgical techniques and ergonomic improvements in the operating theater, SSI remains one of the most frequent types of nosocomial infections.[4] Considering the expected rise in hip fracture admissions that is accompanied with an aging population, the study provides information on an integrated model of care that health care professionals could adopt to improve outcomes of surgical hip patients.

SSI prevention integrative care bundle

A 3-prong (preoperative, intraoperative, and postoperative) SSI prevention integrative care bundle approach informed by best practice guidelines was implemented in the HFU, as illustrated in Table 1. A description of the components in the SSI prevention care bundle can be found in Appendix 1.

Objectives

The objectives of this study were to analyze the effect of an integrative SSI prevention care bundle on the overall SSI incidence among surgical hip patients in an acute HFU and to examine the association between SSI and mortality, readmission, duration of hospitalization, and inpatient bill size. We also include results regarding the following research questions: What is the effect of an integrative SSI prevention care bundle on the overall SSI incidence among surgical hip patients in an acute HFU? Is SSI associated with increased 30-day mortality, 30-day readmission, length of stay, and hospital bill size?

METHODS

A retrospective cohort design was used for this study. Convenience sampling was employed, and all suitable cases from January 1, 2015, to September 30, 2017, were included in the study. The inclusion criteria were patients who underwent hip surgeries within the acute hip unit and patients who developed SSI during their inpatient stay. Patients who developed SSI during their stay fell into the exposure group. Patients without SSI fell into the nonexposure group. The exclusion criteria were patients who opted for conservative management for their hip fracture and patients who developed SSI after discharge.

A minimum sample size was calculated based on comparisons between infected and noninfected groups for 30-day readmission, length of stay, and hospital bill outcomes. Specifically, length of stay is count data and assumed to follow negative binomial distributions instead of traditional Poisson distributions, which assumes equal mean and variance. Given the significance level of .05, at least 200 samples are required to achieve a power of 0.8.[5] For a hospital bill, it is right skewed. We log transformed it and estimated the sample size by comparing means of log-transformed bills between infected and noninfected groups. Given the same significance level, and assuming the ratio of infected and noninfected samples to be 50, at least 204 samples are required to detect a mean difference of 0.5 (SD = 0.33) in log-transformed bills between these 2 groups, and 1,242 samples are required for detecting an odds ratio of 4.2 in the risk of 30-day readmission. The sample size calculation for transformed bills and 30-day readmission were performed by the PS: Power and Sample Size Calculation calculator (Dr. Dupont and Dr. Plummer from School of Medicine, Vanderbilt University, Nashville, TN).

Protocols for the SSI prevention care bundle were standardized in the hip surgery pathway, which promotes bundle compliance. Registration of SSIs was performed by trained orthogeriatricians who routinely performed the surveillance. Patients who developed SSI had their diagnosis documented in the discharge summary by the team doctor on discharge. Thereafter, hip case managers reviewed a patient's discharge summary and documented any SSI incidence in the hip client digital database, should one exist. Indicators such as mortality, readmission, length of stay, and inpatient bill size were retrieved from various central systems across the hospital and input into the hip client digital database by the hip operations team. This mode of data collection started January 2015 and has been ongoing to date.

The demographic and clinical data of all of the study patients were retrospectively retrieved from the hip client digital database available within the hospital. The collected data included the patient's age, gender, race, number of comorbidities, fracture type, door-to-surgery duration, average length of stay, 30-day mortality, 30-day readmission, and inpatient bill size (before government grant). It should be emphasized that this system database was not initiated as a research tool but rather for quality control. The protocol for the retrospective study was approved by the National Healthcare Group Domain Specific Review Board.

Data analysis was performed using IBM Statistical Package for the Social Sciences version 22.0 (SPSS; IBM Corp. in Armonk, NY). All tests were 2-tailed, and $P < .05$ was considered statistically significant. Descriptive statistics were used to summarize the patient demographics and prevalence of SSIs. Mean and SD were used for continuous variables, whereas count and percentage were summarized for categorical variables. Multiple logistic regression was used for modeling association among SSI with 30-day readmission, Poisson regression or negative binomial regression (if appropriate) for length of stay, and gamma regression for inpatient bill size. All of the models were adjusted for age, gender, race, number of comorbidities, fracture type, and door-to-surgery duration.

Table 1
Three-prong SSI prevention integrative care bundle

Preoperative	Intraoperative	Postoperative
Optimize modifiable patient risk factors (eg, diabetes) and nutrition	Antibiotic prophylaxis	Postoperative fever examination, which includes regular wound inspection
Prevention of anemia	Maintaining body core temperature: Preventing intraoperative hypothermia	Prevent wound contamination
Preoperative skin preparation with chlorhexidine body wash to reduce skin microflora	Prevention of anemia	Optimize nutrition Prevention of anemia
Screening and isolation of surgical hip patients from patients with MRSA	—	Early mobilization and discharge planning

NOTE. Model is adjusted for age, gender, race, number of comorbidities, fracture type, and door-to-surgery duration.
MRSA, methicillin-resistant *Staphylococcus aureus*; *SSI*, surgical site infection.

Table 2
Demographic characteristics of surgical hip patients

Demographic characteristic	Total no. of surgical patients (N = 758)	Patients with SSI (N = 14)	Patients without SSI (N = 744)
Age	78.6 ± 8.8	77.3 ± 10.0	78.6 ± 8.8
Gender (%)			
Male	225 (29.7)	4 (28.6)	221 (29.7)
Female	533 (70.3)	10 (71.4)	523 (70.3)
Race (%)			
Chinese	610 (80.5)	10 (71.4)	600 (80.6)
Malay	97 (12.8)	2 (14.3)	95 (12.8)
Indian	38 (5.0)	2 (14.3)	36 (4.8)
Others	13 (1.7)	0 (0)	13 (1.7)
No. of comorbidities	4 (2-6)	3 (2-8)	4 (2-6)
Type of fracture (%)			
Neck of femur	372 (49.1)	3 (21.4)	369 (49.6)
Intertrochanteric	367 (48.4)	11 (78.6)	356 (47.8)
Subtrochanteric	19 (2.5)	0 (0)	19 (2.6)
Door to surgery (%)			
Within 48 h	357 (47.1)	9 (64.3)	348 (46.8)
>48 h	401 (52.9)	5 (35.7)	396 (53.2)

NOTE. Model is adjusted for age, gender, race, number of comorbidities, fracture type, and door-to-surgery duration.
SSI, surgical site infection.

RESULTS

Demographics

A total of 758 patients underwent hip surgeries from January 2015 to September 2017. Table 2 presents the demographic characteristics of the surgical hip patients. Of these, approximately one-half sustained a neck of femur fracture (n = 372, 49.1%), whereas the other half sustained either an intertrochanteric (n = 367, 48.4%) or a subtrochanteric (n = 19, 2.5%) fracture. Approximately one-half (n = 357, 47.1%) of the patients managed to undergo surgery within 48 hours of admission. The sample was made up of predominantly Chinese patients (n = 610, 80.5%). There were 225 (29.7%) men and 533 (70.3%) women, with an average age of 78.6 ± 8.8 years and an average number of 4 comorbidities.

Incidence of SSIs

The incidence of SSIs during the study period is presented in Table 3. Among the 758 patients, a total of 14 SSIs were documented, giving an overall infection rate of 1.8%. There was a steady decrease in the incidence of SSIs over the years, with the latest data standing the lowest at 1.4%.

Outcomes of patients with and without SSIs

The outcomes of patients with and without SSIs are summarized in Table 4. Notably, none of our patients who developed SSIs during their hospitalization passed away within 30 days. However, 7 patients (0.9%) with no SSI passed away within 30 days.

Association between SSIs and outcomes

Table 5 presents the association between SSI and 30-day mortality, 30-day readmission, average length of stay, and inpatient bill size. Patients with SSI were 4.27 times (95% confidence interval [CI], 1.03-15.29; $P = 0.03$) more likely to be readmitted within 30 days than patients with no SSI. Patients with SSI had 2.47 times (95% CI, 1.95-3.17; $P < .001$) longer length of stay than patients with no SSI. The inpatient bill size for patients with SSI was 2.15 times (95% CI, 1.73-2.71; $P < 0.001$) that of patients with no SSI.

Table 3
Incidence of SSI

	2015	2016	Jan 2015-Sept 2017	2015-Sept 2017
No. of surgical cases	263	279	216	758
No. of patients with SSI (%)	6 (2.3)	5 (1.8)	3 (1.4)	14 (1.8)

NOTE. Model is adjusted for age, gender, race, number of comorbidities, fracture type, and door-to-surgery duration.
SSI, surgical site infection.

Correlation between SSIs and door-to-surgery time

The correlation between categorical door-to-surgery time (Table 2) and SSI incidence is 0.046, as estimated by Cramer's V.[6]

DISCUSSION

Our acute hip unit admits patients who are older than 60 years, which explains the high average number of comorbidities among the study patients. Despite the vulnerability of the study population, the prevalence of SSI in the current study was 1.8%, which is below the reported local prevalence of 4.3% and international prevalence of 4.97%-10%.[7-10] Such a low rate reflects the effectiveness of the integrative SSI prevention care bundle in keeping the SSI incidence low in an acute hip unit. This could be attributed to the study's emphasis on the use of an integrative care bundle approach informed by best practice guidelines to prevent SSI in an acute hip unit. This strategy is in accordance with the 3 themes identified in a recent integrative review on reducing the risk of SSI, which included employing a care bundle approach, promoting shared responsibility, and adhering to best practices.[11]

The multifaceted nature of the SSI prevention care bundle makes it difficult to establish which element contributed most to the reported reduction in SSI incidence in the study. Additionally, the system database was not initiated as a research tool but rather for quality control, and therefore causality could not be established. However, the team recognizes that the use of targeted local measures to optimize evidence-based processes of care, including introduction of a wound inspection protocol that mandates a senior doctor to inspect the wound on the designated postoperative day according to

Table 4
Outcomes of patients with and without SSI

Outcomes	Total no. of surgical patients (N = 758)	Patients with SSI (N = 14)	Patients without SSI (N = 744)
ALOS (d)	11 (8-15)	24 (11-45)	11 (8-15)
30-d mortality (%)	7 (0.9)	0 (0)	7 (0.9)
30-d readmission (%)	70 (9.2)	4 (28.6)	66 (8.9)
Inpatient bill size ($)	18,583 (16,199-22,173)	27,010 (18,058-58,292)	18,502 (16,185-22,037)

NOTE. Model is adjusted for age, gender, race, number of comorbidities, fracture type, and door-to-surgery duration.
ALOS, average length of stay; *SSI*, surgical site infection.

Table 5
Association between SSI and outcomes

Outcomes	Exp (B)	95% CI	*P* value
30-d mortality (%)	—	—	—
30-d readmission (%)	4.27	1.03-15.29	.03
ALOS (d)	2.47	1.95-3.17	<.001
Inpatient bill size ($)	2.15	1.73-2.71	<.001

NOTE. Model is adjusted for age, gender, race, number of comorbidities, fracture type, and door-to-surgery duration.
ALOS, average length of stay; *CI*, confidence interval; *SSI*, surgical site infection.

the nature of the hip operation, involvement of the infectious disease physician to promote appropriate antibiotic prophylaxis and clinically rational antibiotic prescribing, and standardization of all surgical wound dressings with proper documentation to reduce unnecessary manipulation of wound dressing, are key components of the care bundle in effecting the change in outcome.

SSI has been reported to be associated with longer hospitalizations, higher readmission and mortality, and increased cost.[1,12,13] The present study also demonstrated that SSIs prolonged the hospital stay by more than twice the duration, quadrupled readmission rates, and increased health care cost by more than 100%. Notably, none of our patients who developed an SSI during their hospitalization passed away within 30 days.

Our study reinforced that SSIs are burdensome for both the patient and the health care system in terms of morbidity and economic burden. Consequently, preventive efforts aimed at reducing the incidence of SSIs could improve the efficiency of the health care system and result in substantial cost savings. The traditional model of hip fracture care is composed of patients fully under the care of orthopedic surgeons. There was a lack of coordination between different disciplines and a standardized approach to surgical site care, which resulted in fragmentation and inefficiency. SSI prevention is complex. There are numerous factors that can increase patients' risk of SSI during the perioperative phase. Therefore, effective SSI prevention extends beyond the care of orthopedic surgeons and should engage stakeholders across various hospital departments. Each health care professional has a unique role and should take accountability to reduce the chance of SSIs at every step during the perioperative phase.

Clinical implications

SSI prevention was standardized by embedding necessary investigations and management plans into the hip surgery pathway, which promotes bundle compliance. The integrative SSI prevention care bundle runs in an autonomous and systematic fashion with existing resources that benefits patients and the hospital. This model of care could therefore be replicated to improve outcomes of surgical hip patients.

Limitations

First, given that this is a retrospective study, it is particularly prone to information bias. Second, we only included patients who developed SSI during their stay in the acute hip unit. It is possible that some patients developed SSI following discharge. Since the data were not captured by the team, the reported SSI incidence could be underrepresented. Finally, another limitation of our study is the wide CI for 30-day readmission. This is because of a big standard error attributed to an insufficient sample size. Even though our current sample size is considerably large, it is still not enough to get an accurate estimate of the odds ratio, and therefore the standard error is large and the CI is wide.

Recommendations for future research

Future research could consider employing a prospective design to compare the SSI incidence before and after implementation of the SSI prevention care bundle. Additionally, further studies could consider evaluating the effectiveness of patient-focused interventions in SSI prevention such as patient education on postdischarge SSI considering that they are the primary stakeholders who bear the direct consequences of SSI.

CONCLUSIONS

The use of an integrative SSI prevention care bundle approach informed by best practice guidelines promoting shared responsibility among multidisciplinary team members has demonstrated to be effective in preventing SSIs among surgical hip patients. Implementation of evidence-based guidelines requires a coordinated multidisciplinary approach as we transit from silos of care to a collaborative approach. Clearly, an integrative team-based approach that capitalizes on the strengths and expertise of various groups of heath care professionals is more likely to result in better patient outcomes as we continue to work toward reducing the incidence of SSIs among our surgical hip patients.

APPENDIX 1. DESCRIPTION OF THE COMPONENTS IN THE SURGICAL SITE INFECTION PREVENTION CARE BUNDLE

Preoperative

Optimize modifiable patient risk factors and nutrition

Chronic conditions and malnutrition are significant risk factors for the development of surgical site infection (SSI). As part of the preoperative management, a standard care plan and guidelines for prevention of complications and management of chronic conditions such as diabetes will be executed by a geriatrician who seeks to optimize patients' health conditions before they are sent for surgery.

A dietician will seek to optimize the patient's nutritional status for surgery. Instead of the conventional way of keeping the patient nil-

by-mouth from midnight on the surgery day, preoperative nutrition support in the form of clear glucose drinks (100 g of glucose) are prescribed by the dietitian and given to the patient on the night before surgery and another drink (50 g of glucose) up to 4 hours before the surgery.

Prevention of anemia

Anemia contributes to the development of SSI following hip surgeries. Prevention of anemia spans all of the 3 operative phases. The patient's hemoglobin level will be kept above 9-10g/dL, with blood transfusion as indicated. Oral iron therapy together with vitamin C will be prescribed pre- and postoperatively. In addition to promoting iron absorption, vitamin C also boosts immunity and promotes wound healing.

Preoperative skin preparation

Reducing skin flora, a result of preoperative skin preparation, may lower the risk of developing SSI. Nurses will perform chlorhexidine body sponging for all patients who are scheduled for surgery at 8:00 PM the night before surgery as well as at 6:00 AM on the day of surgery.

Screening and isolation

Methicillin-resistant *Staphylococcus aureus* (MRSA) has been reported to be the most common organism responsible for SSI.[4] Routine preoperative screening for MRSA colonization is carried out in the unit by nurses to identify the colonized patients. Surgical hip fracture patients will strictly be isolated from MRSA-colonized patients to prevent cross-infection. Early identification of a MRSA surgical hip fracture patient also aids in choosing appropriate antibiotics if SSI develops.

Intraoperative

Antibiotic prophylaxis

A total of 3 doses of intravenous antibiotic will be infused within 1 hour before incision and discontinued within 24 hours of surgery completion. Patients with MRSA will be administered vancomycin, whereas noninfected patients will be administered cefazolin.

Maintaining body core temperature

Hypothermia is a risk factor for SSI because it increases sensitivity to infections attributed to immunity impairment and vasoconstriction. The surgical team proactively prevents hypothermia through the use of air warmers, heated operating theaters, routine use of air warming, and an intravenous fluid–warming device, as well as improved intraoperative monitoring and documentation of temperature.

Postoperative

Postoperative fever examination with a wound inspection protocol

An active surveillance program aids in early management and prevention of SSI. Guidance on postoperative fever examination, which includes routine wound inspection, will be performed by a senior doctor. All surgical intertrochanteric fracture patients will have their wound inspected on the seventh postoperative day (POD), whereas all surgical neck of femur patients will have their wound inspected on the second and the seventh POD.

Prevent wound contamination

Most surgical wounds heal by primary intention. For healing to take place at an optimum rate, the wound should avoid being disturbed by frequent or unnecessary dressing changes. Standardization was made to all wound dressings to be labeled with the date and time of dressing change, together with the use of photographs, to track wound progress and to prevent health care providers from removing the dressing unnecessarily.

Optimize nutrition postsurgery

Malnourished patients have compromised immunity that puts them at significantly higher risk for developing SSI. Additionally, patients who are malnourished are at risk of delayed wound healing. Therefore, all patients will be prescribed a high-energy and high-protein diet by the dietician, both of which are essential for the wound healing process.

Early mobilization and discharge planning

Physiotherapists and occupational therapists seek to improve mobility and function postsurgical intervention to facilitate recovery and discharge. Patients will receive daily physical and occupational therapy for the first 3 days postsurgery. Discharge planning starts soon after the patient's admission into the unit. A case manager will review and discuss discharge plans with patients and caregivers. Referral to a community hospital will be initiated on the first POD and completed by the third POD. These help decrease the patients' length of hospitalization stay, which in turn reduce their risk of exposure to SSIs.

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