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Factors affecting surgical site infection rate after elective gastric cancer surgery

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ABSTRACT

Objective: Surgical site infection (SSI) is a common complication after surgery and is an indicator of quality of care. Risk factors for SSI are studied thoroughly for most types of gastrointestinal surgeries and especially colorectal surgeries, but accumulated data is still lacking for gastric surgeries. We studied the parameters affecting SSI rate after gastric cancer surgery.

Material and Methods: Consecutive patients, who underwent elective gastric cancer surgery between June and December 2013, were included. Descriptive parameters, laboratory values and past medical histories were recorded prospectively. All patients were followed for 1 month. Recorded parameters were compared between the SSI (+) and SSI (-) groups.

Results: Fifty-two patients (mean age: 58.87±9.25 [31-80]; 67% male) were included. SSI incidence was 19%. ASA score ≥3 ($p<0.001$), postoperative weight gain ($p<0.001$), smoking ($p=0.014$) and body mass index (BMI) ≥30 ($p=0.025$) were related with a higher SSI incidence. Also patients in the SSI (+) group had a higher preoperative serum C-reactive protein level ($p=0.014$).

Conclusion: We assume that decreasing BMI to <30, stopping smoking at least 3 weeks before the operation, and preventing postoperative weight gain by avoiding excessive intravenous hydration will all help decrease SSI rate after gastric surgery.

Keywords: Gastric cancer, surgical site infection, risk factors

INTRODUCTION

The incidence of gastric cancer has been decreasing throughout the last decades after effective eradication of Helicobacter pylori infection, improved sanitation, refrigeration and a shift towards the consumption of fresh fruit and vegetables rather than red meat and high fat diet (1, 2). Nevertheless, gastric cancer still remains to be the third most common cause of cancer related deaths (3), and gastric cancer surgery is a commonly performed surgery in especially busy tertiary care centers.

Surgical site infections (SSI) are responsible for 38% of nosocomial infections (4, 5), and is one of the most prominent morbidity after gastric surgery. Surgical site infections causes prolonged hospitalization and increased surgery related costs (6, 7). ASA score, wound classification and duration of the operation are the 3 SSI-related factors established by the National Nosocomial Infection Surveillance (NNIS) (8-10). Risk factors for SSI are studied thoroughly for most types of gastrointestinal surgeries and especially colorectal surgeries, but accumulated data is still lacking for gastric surgeries (11, 12).

Our hospital is a tertiary care center with more than 200 gastric cancer surgeries a year. In our clinic, we experience a higher SSI rate than the stated rate (3-16%) for gastric surgeries in the literature (13-15). In this study, our goal is to determine the factors affecting SSI rate after gastric surgery.

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MATERIAL AND METHODS

Patients and Study Design

The subjects of our prospective observational cohort study were consecutive patients who underwent elective gastric surgery (distal subtotal or total gastrectomy with D2 lymphadenectomy) for gastric cancer. The inclusion criteria were: (1) patients diagnosed with resectable gastric cancer and undergoing laparotomy; (2) being older than 18 years of age; (3) giving informed consent to participate in the study. The exclusion criteria were: (1) signs of a clinically prominent infection detected on the day of admission; (2) an ASA score of ≥4; (3) laparoscopic surgery (seldomly performed in our clinic for gastric cancer surgery).

Data Collection

Patient age, gender, ASA score, BMI, history of co-morbidities as diabetes mellitus (DM) and chronic obstructive pulmonary disease (COPD), type of surgery, anastomosis technique (hand-sutured vs. stapled), operation duration, blood transfusion, ICU admission, tumor stage, body weight on the day of hospital admission, daily changes in body weight postoperatively, length of hospital stay, readmission to the hospital, hospital costs, preoperative and postoperative laboratory studies were recorded prospectively. In the NNIS report, the operation duration was grouped according to the third percentile which was 180 minutes for gastric cancer surgeries (16, 17). We also used third percentile as a cut-off point which was 135 minutes in our study. Patients were followed one month for SSI. They were asked to visit the outpatient clinic on postoperative day 15 and day 30. Although it is not routinely done in our clinic for all surgical site infections, swab culture was obtained from all patients during the diagnosis of SSI for this study.

Definitions

All patients were operated by a single surgeon with more than 25 years of experience. Surgical residents assisted during the surgery and no students scrubbed in. In our institution, we remove hair using a clipper 30 minutes before surgery in the operating room. We use povidone-iodine as the antiseptic solution. For prophylaxis, we use first generation cephalosporins. If the patient is allergic to penicilline then we use fluoroquinolones. In this study, no patient was allergic to penicilline thus fluoroquinolones were never used.

Blood tests were taken on the day of hospital admission. Body weight was also measured on the day of admission and each postoperative day. Mean values for postoperative body weight measurements were calculated and compared to the body weight measurement on the hospital admission day. If the mean postoperative body weight was more than the admission day body weight, the patient was accepted as 'gained weight' postoperatively. Patients who never smoked or stopped smoking prior to 3 weeks before surgery were considered as nonsmokers.

The criterias used to define and classify SSI's were established according to the guidelines of the Committee of Disease Control (CDC) (Table 1) (4, 18, 19). Our study is designed and conducted according to the Helsinki declaration.

Statistical Analysis

Student's t test was used to compare continous variables, while *chi-square* test was used to compare categorical values. Statistical Package for Social Sciences (SPSS) software version 18.0 (SPSS Inc., Chicago, IL, USA) was used for statistical analysis. A p value less than 0.05 was considered as statistically significant.

RESULTS

In this study, 52 patients were included from June to December 2013. The mean age was 58.87±9.25 [31-80] years. The proportion of males was 67% (n=35) in our cohort. 21% (n=11) of

Table 1. Center for disease control classification of surgical site infection
Superficial Incisional SSI
Infection within 30 days after the operation and only involves skin and subcutaneous tissue of the incision and at least one of the following:
• Purulent drainage with or without laboratory confirmation, from the superficial incision.
• Organisms isolated from an aseptically obtained culture of fluid or tissue from the superficial incision.
• At least one of the following signs or symptoms of infection: pain or tenderness, localized swelling, redness, or heat and superficial incision is deliberately opened by surgeon, unless incision is culture-negative.
Diagnosis of superficial incisional SSI made by a surgeon or attending physician.
Deep Incisional SSI
Infection occurs within 30 days after the operation if no implant is left in place or within one year if implant is in place and the infection appears to be related to the operation and infection involves deep soft tissue (e.g. fascia, muscle) of the incision and at least one of the following:
• Purulent drainage from the deep incision but not from the organ/space component of the surgical site.
• A deep incision spontaneously dehisces or is deliberately opened by a surgeon when the patient has at least one of the following signs or symptoms: fever (>38°C), localized pain or tenderness, unless incision is culture-negative.
• An abscess or other evidence of infection involving the deep incision is found on direct examination, during reoperation, or by histopathologic or radiologic examination.
Diagnosis of deep incisional SSI made by a surgeon or attending physician.
Organ/Space SSI
Infection occurs within 30 days after the operation if no implant is left in place or within one year if implant is in place and the infection appears to be related to the operation and infection involves any part of the anatomy (e.g., organs and spaces) other than the incision which was opened or manipulated during an operation and at least one of the following:
• Purulent drainage from a drain that is placed through a stab wound into the organ/space.
• Organisms isolated from an aseptically obtained culture of fluid or tissue in the organ/space.
• An abscess or other evidence of infection involving the organ/space that is found on direct examination, during reoperation, or by histopathologic or radiologic examination.
Diagnosis of organ/space SSI made by a surgeon or attending physician.
SSI: Surgical site infection

the patients had a family history of gastric cancer. 14% (n=7) of the patients had an ASA score of ≥3. 23% (n=12) of the patients had a BMI of ≥30. 37% (n=19) of the patients were smoking. 8% (n=4) of the patients had a diagnosis of COPD and 14% (n=7) of the patients had a diagnosis of DM (Table 2).

In our study, 55% (n=28) of the patients had a tumor stage ≥3. 54% (n=28) of the patients had a distal subtotal gastrectomy and 46% (n=24) had a total gastrectomy. The mean operation duration was 130.47±50.48 [45-300] minutes. 27% (n=14) of the patients received blood transfusion during their hospital stay. 23% (n=12) of patients were transferred to the ICU after surgery. 23% (n=12) of the patients gained weight after surgery. Mean discharge day was 5.29±3.05 [3-24]. The readmission rate was 6% (n=3). The mean hospital cost was 5305.77±2268.94 [1933-13603] USD (Table 2).

The incidence of SSI was 19% (n=10). All patients diagnosed with SSI had a superficial incisional infection. 50% (n=5) of the SSI's occurred during the hospital stay while the other 50% (n=5) were diagnosed on the 15th day outpatient clinic visit (Table 3). From the swab culture of 1 patient, group G streptococcus "*Streptococcus disgalactia* and *Streptococcus anginosus*" were obtained. *Enterobacter aerogenes* was obtained from the swab culture of another patient. *Staphylococcus epidermidis* and *Streptococcus mitis* were obtained from the swab cultures of 8 patients in the SSI (+) group (Table 4).

When the SSI (+) and SSI (-) groups were compared an ASA score of ≥3, a BMI of ≥30, and smoking history were more commonly encountered in the SSI (+) group (50% vs. 5%, p<0.001; 50% vs. 17%, p=0.025 and 70% vs. 29%, p=0.014, respectively). Postoperative weight gain was also more common in the SSI (+) group (70% vs. 12%, p<0.001) (Table 5). Patients in the SSI (+) group had a higher preoperative serum C-reactive protein value in comparison to the other group (60.44 (±54.31) mg/L vs. 19.38 (±17.69) mg/L; p=0.01) (Table 6).

Age, gender, tumor stage, co-morbidities (COPD and DM), type of surgery, anastomosis technique, operation duration, blood transfusion, ICU admission, length of hospital stay, readmission rate and hospital costs were similar between the two groups (Table 5).

DISCUSSION

The incidence of gastric cancer is inclined to decrease in the past decades. Nevertheless, gastric cancer surgery is still frequently performed in tertiary care hospitals. According to various studies in the literature, SSI is one of the most common comorbidities after gastric surgery with an incidence of 3-28% (5, 13-15). Factors affecting SSI after colorectal surgery is thoroughly studied in the literature (11, 12), but data still needs to be accumulated for gastric surgery.

The incidence of SSI was 19% in our study. Although our rate was similar to the rates reported from other developing countries (5), it was above the rates reported from developed countries (13, 14). When we compared the SSI (+) and SSI (-) groups an ASA score of ≥3, a BMI of ≥30, postoperative weight

Table 2. Descriptive factors	
Age (years) (mean±SD [Range])	58.87±9.25 [31-80]
Gender, n (%)	
Male	35 (67)
Female	17 (33)
Family history of gastric cancer, n (%)	11 (21)
ASA score ≥3, n (%)	7 (14)
BMI ≥30 (kg/m²) n (%)	12 (23)
Smoking history, n (%)	19 (37)
Diagnosis of COPD, n (%)	4 (8)
Diagnosis of DM, n (%)	7 (14)
Tumor stage ≥3, n (%)	28 (55)
Surgery type, n (%)	
Distal subtotal gastrectomy	28 (54)
Total gastrectomy	24 (46)
Operation duration (minutes) (mean±SD[Range])	130.47±50.48 [45-300]
Receiving blood transfusion, n (%)	14 (27)
ICU admission, n (%)	12 (23)
Patients gained weight after surgery, n (%)	12 (23)
Hospital stay (day) (mean±SD[Range])	5.29±3.05 [3-24]
Readmission rate, n (%)	3 (6)
Hospital cost (USD) (mean±SD [Range])	5305.77±2268.94 [1933-13603]

COPD: chronic obstructive pulmonary disease; DM: diabetes mellitus; USD: United States dollars. BMI: body mass index; ICU: intensive care unit

Table 3. SSI incidence and types	**n (%)**
Incidence of SSI	10 (19)
SSI classification	
Superficial	10 (100)
Deep	0 (0)
Organ/space	0 (0)
Date of SSI diagnosis	
During hospital stay	5 (50)
Postoperative day 15	5 (50)
Postoperative day 30	0 (0)

SSI: surgical site infection

Table 4. Swab culture results	**n (%)**
Group G *Streptococcus*	
S. disgalactia	1 (5)
S. anginosus	1 (5)
Enterobacter aerogenes	1 (5)
Staphylococcus epidermidis	8 (42)
Streptococcus mitis	8 (42)

Table 5. Comparison of descriptive factors	SSI (-)	SSI (+)	p
Age (years) (mean [±SD])	58.38 (±10.87)	60.9 (±7.62)	0.4
Gender, n (%)			
Male	30 (71)	5 (50)	0.194
Female	12 (29)	5 (50)	
ASA score, n (%)			
<3	40 (95)	5 (50)	<0.001 OR 20 [3-131.7]
≥3	2 (5)	5 (50)	
BMI (kg/m^2) n (%)			
<30	35 (83)	5 (50)	0.025 OR 5 [1.1-2.2]
≥30	7 (17)	5 (50)	
Smoking history, n (%)			
Negative	30 (71)	3 (30)	0.014 OR 5.8 [1.3-26.4]
Positive	12 (29)	7 (70)	
COPD, n (%)			
COPD (-)	39 (93)	9 (90)	0.761
COPD (+)	3 (7)	1 (10)	
DM, n (%)			
DM (-)	36 (86)	9 (90)	0.721
DM (+)	6 (14)	1 (10)	
Anastomosis technique, n (%)			
Hand-sutured	34 (85)	7 (78)	0.712
Stapled	6 (15)	2 (22)	
Operation duration (minutes) n (%)			
<135	28 (78)	6 (67)	0.732
≥135	8 (22)	3 (33)	
Erythrocyte suspension transfusion, n (%)			
Transfusion (-)	31 (74)	7 (70)	0.807
Transfusion (+)	11 (26)	3 (30)	
Intensive care unit admission, n (%)			
Admission (-)	37 (88)	3 (30)	0.761
Admission (+)	5 (12)	7 (70)	
Postoperative weight gain, n (%)			
Weight gain (-)	37 (88)	3 (30)	<0.001 OR 17.3 [3.3-89.3]
Weight gain (+)	5 (12)	7 (70)	
Type of surgery, n (%)			
Distal subtotal gastrectomy	22 (52)	6 (60)	0.664
Total gastrectomy	20 (48)	4 (40)	
Tumor stage, n (%)			
<3	16 (39)	7 (70)	0.182
≥3	25 (61)	3 (30)	
Discharge day (mean [±SD])	5.27 (±3.24)	5.4 (±2.22)	0.88
Readmission n (%)	2 (4.8)	1 (10)	0.65
Hospital cost (USD) (mean [±SD])	2596 (±1131)	2235 (±814)	0.26

SSI: surgical site infection; COPD: chronic obstructive pulmonary disease; DM: diabetes mellitus; USD: United States dollars. BMI: body mass index

Table 6. Comparison of preoperative laboratory tests

	SSI (-) Mean (±SD)	SSI (+) Mean (±SD)	p
Carcinoembryogenic antigen (ng/mL)	10.07 (±7.62)	2.67 (±2.17)	0.28
Hemoglobin (g/dL)	11.12 (±2.28)	11.13 (±2.01)	0.99
Hematocrit (%)	33.58 (±6.09)	33.03 (±5.5)	0.79
White blood cells (uL)	7816 (±2131)	7920 (±2225)	0.89
Platelet (uL)	284404 (±101993)	324100 (±112620)	0.33
Glucose (mg/dL)	93.88 (±22.78)	97.50 (±19.14)	0.61
Total protein (g/dL)	6.75 (±0.46)	5.83 (±0.47)	0.2
Albumin (g/dL)	3.91 (±0.71)	3.78 (±0.3)	0.4
Blood urea nitrogen (mg/dL)	16.21 (±5.91)	16.18 (±5.60)	0.99
Creatinine (mg/dL)	0.99 (±0.1)	0.85 (±0.39)	0.33
C-reactive protein (mg/L)	19.38 (±17.69)	60.44 (±54.31)	0.01

SSI: surgical site infection

gain during hospital stay, smoking history, and preoperative high CRP values were significantly more common in the SSI (+) group.

Patients who gained weight during the postoperative period were more commonly diagnosed with SSI in our study. The most common reason of weight gain during the early postoperative period is excessive IV fluid administration. Excessive IV fluid causes an increase in body weight and effects the mobility of the patient negatively. It also impairs tissue oxygenation by accumulating in the interstitial space and raises susceptibility to SSI (20, 21). We think that balancing IV fluid treatment meticulously and measuring patient weight on a daily basis will help decrease SSI incidence.

Impaired tissue oxygenation is also encountered among smoking individuals. It is well established that nicotine use delays primary wound healing and increases the risk of SSI by reducing the amount of oxygen carried to the wound by red blood cells (22, 23). Also in our study smoking history was significantly more common in the SSI (+) group. Stopping smoking at least 3 weeks before surgery will reduce susceptibility of the patient to SSI after gastric surgery.

When the ASA score was first generated, the goal was not to predict the SSI risk but anesthetic procedure related morbidity and mortality (22). Nevertheless, during the following years ASA score has become a predictor of underlying disease severity and susceptibility of the patient to SSI. In the literature, studies have been published reporting a correlation between ASA score and SSI (8, 24-26). In our study, ASA scores of 3 and 4 were found more commonly in the SSI (+) group. We think that ASA score is a reliable factor that aids the surgeon in defining the susceptibility of the patient to SSI.

In our study, subjects with a BMI over 30 were more prone to SSI. The correlation between BMI and SSI was reported in the literature repeatedly (14, 27, 28). The composition of adipose tissue is relatively avascular, and a wound with a higher amount of adipose tissue will have a lower tissue oxygenation. Similar to the mechanism which excessive IV fluid causes susceptibility to SSI, the less oxygenated adipose tissue is more prone to SSI. Also technical difficulties in obese patients and necessity of a wider incision all contribute to the SSI risk of the obese patient (29, 30). The interval between diagnosis and surgery is generally not long in gastric cancer patients, and the patient might not be able to lose a considerable amount of body weight. In our clinic, there is usually a 2-3 week interval between the time of diagnosis and surgery. Taking into consideration the fact that obese patients lose weight more rapidly, we think it is reasonable to advise the patient on the date of diagnosis to lose as much weight as possible before surgery under the supervision of a dietician.

In the SSI (+) group, patients had significantly higher preoperative serum CRP levels. As an acute-phase reactant CRP level can increase due to an underlying infection. It can also be elevated in numerous noninfectious inflammatory processes (31). Serum CRP value is a marker of chronic systemic inflammation and is positively associated with the amount of adipose tissue in a healthy individual. Obese individuals tend to have twice as high CRP levels as normal body weight individuals (32-34). We think that the reason of higher CRP levels in the SSI (+) group was because more patients with a BMI ≥30 were within this group. We don't think that routine preoperative CRP level measurement will help decrease the SSI rate.

Most of the studies in the literature reporting operation duration as a factor affecting SSI rate were conducted in multiple centers with different expertise levels of surgeons and various operation durations (13). In our study, the operation duration was slightly higher in the SSI (+) group but the difference was not statistically significant. A single surgeon with more than 25 years of experience operated on all the patients, and similar operation durations were obtained for most cases. We think that operation duration is a factor reflecting the expertise level of the surgical team. Because of the single center design of our study, operation duration was not found as a factor affecting the SSI rate.

Although this study can be criticized with it's small cohort size, according to our knowledge, postoperative weight gain was previously not reported as an SSI related factor after gastric surgery, and our study will make a contribution to the literature.

CONCLUSION

We assume that decreasing BMI to <30, stopping smoking at least 3 weeks before the operation, and preventing postoperative weight gain by avoiding excessive IV hydration will all help decrease SSI rate after gastric surgery.

Ethics Committee Approval: Authors declared that the research was conducted according to the principles of the World Medical Association Declaration of Helsinki "Ethical Principles for Medical Research Involving Human Subjects", (amended in October 2013).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

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