Incidence of surgical site infection in patients undergoing emergency laparotomy for blunt abdominal trauma

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Background
The rising incidence of blunt abdominal trauma increases the rate of hospital admissions for those cases worldwide, with some of them undergoing emergency laparotomy. Surgical site infection for those patients is still not an uncommon complication, which deserves great attention to be prevented or adequately managed if established. The aim of the study was to focus on the incidence of this complication along with factors that may affect its occurrence.
Patients and methods
The study was conducted at the general surgery emergency department of Kasr Al-Aini Cairo University hospital from July 2019 through February 2020. It included 30 patients who presented with blunt abdominal trauma and needed emergency laparotomy and then were observed for the occurrence of surgical site infection. Patients were individually correlated to a risk factor scoring system, which we had formulated to be used in the study.
Results
Overall, 20% of the patients had surgical site infection. The study showed increased incidence of postoperative SSI in patients with higher risk factor total score (score $>$ 7) and low incidence with scores below that, with a significant relation (P value $<$ 0.001).
Conclusion
The scoring system was helpful in the prediction of surgical site infection in the studied patient group.

Keywords:
blunt abdominal trauma, emergency lapa[rotomy, risk factor scoring system, surgical site infection

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Introduction

Surgical site infections continue to occur at an unacceptable rate, annually costing billions of dollars in economic loss caused by associated morbidity and mortality [1].

Blunt abdominal trauma is one of the most important causes of case admissions in the emergency surgery department worldwide, and a percentage of these patients undergo emergency laparotomy according to meticulous clinical case evaluation [2].

The most common mechanisms are motor vehicle crashes, motorcycle driving, pedestrian collision, fall greater $>$ 1 meter, and assault. The most commonly injured organs are liver, spleen, kidney, mesentery, omentum, and colon [3].

Criteria for diagnosis of SSI

The USA Centers for disease control (CDC) states that only infections occurring within 30 days of surgery (or within a year in case of implants) should be classified as surgical site infections (SSI) [4,5].

SSI is split into 3 groups: superficial SSI, deep SSI, and organ/space SSI.

Superficial SSI must meet the following 2 criteria:

(1) Occur within 30 days of procedure.
(2) Involve only skin and subcutaneous tissue around the incision.

In addition to at least one of the following criteria:

(1) Purulent drainage from the incision.

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(2) Organisms isolated from an aseptically obtained culture of fluid/tissue from the incision.
(3) At least one of the following signs or symptoms of infection:
   (a) Pain/ tenderness at incision site.
   (b) Localized swelling.
   (c) Erythema or increased temperature [1,2,5,6].

Deep Incisional surgical site infection

(1) It involves deep soft tissues such as fascia or muscle within incision and occurs within 30 days postoperatively without implant.
(2) It occurs within 1 year if implant is in place.
(3) Infection appears to be directly related to surgical procedure [3,6] and must fulfill one of the following additional criteria:
   (a) Purulent drainage from incision but not from the organ/space of the site.
   (b) Dehiscence or deliberate opening by the surgeon from the deep incision when the patient has at least one of the following signs or symptoms of clinical infection: fever greater than 100.4 °F, localized pain, or edema, unless culture is negative.
   (c) Abscess or other evidence of infection involving the deep incision is found during examination of incision, reoperation, or pathologic or radiologic examination [7,8].

Organ/space surgical site infection

Organ/space surgical site infection involves any part of the anatomy other than the incision, occurs within 30 days postoperatively without implant, occurs within 1 year if implant is in place, and infection appears to be directly related to surgical procedure [2,6], and must fulfill one of the following:

(1) Purulence from a drain deeply inserted in or related to surgical site.
(2) Isolated organisms from aseptically obtained fluid or tissue from the organ/space.
(3) Abscess or other evidence of infection involving the deep incision is found during examination of incision, reoperation, or pathologic or radiologic examination [1,7,8].

Abdominal trauma remains a leading cause of mortality in all age groups. Blunt abdominal injury (BAI) is common and usually results from motor vehicle collisions (MVC), falls, and assaults. In children (less than or equal to 14 years of age), blunt abdominal trauma is the second most frequent cause of mortality preceded by head injuries. Injuries in the abdomen occur from direct forces causing compression or shearing-type injuries or deceleration injuries that result in damage to relatively fixed structures. The most common organ injured is the spleen, followed by the liver and the small bowel [9,10].

Blunt force injuries to the abdomen can generally be explained by 3 mechanisms. The first mechanism is deceleration; the second mechanism involves crushing, where intra-abdominal contents are crushed between the anterior abdominal wall and the vertebral column or posterior thoracic cage; and the third mechanism is external compression, whether from direct blows or from external compression against a fixed object, e.g., lap belt and spinal column [11,12].

Trauma laparotomy should be performed if indicated using the damage control approach, which has reduced mortality in patients with severe abdominal injuries [11].

Indications/predictors for laparotomy

The following are the indications or predictors for laparotomy:

Hemodynamic instability.

Evidence of peritonitis to achieve control of hemorrhage and control of spillage.

Traumatic diaphragmatic injury with herniation.

Severe solid organ injury (e.g., kidney and spleen).

Infarction owing to post-traumatic occlusion of the blood supply.

Mesenteric tear/s.

Unexplained moderate to large amounts of free fluid (200–≥500mls).

Failed nonoperative management [11–13].

Patients and methods

This prospective observational cohort study included 30 patients who underwent emergency laparotomy because of blunt abdominal trauma in the general surgery emergency department at Kasr Al-Aini emergency hospital, with written consent, to calculate the incidence of surgical site infections (SSI) along with the main risk factor regardless of age and sex.

Inclusion criteria

The following were the inclusion criteria:

(1) Patients undergoing emergency laparotomy for blunt abdominal trauma.
(2) All age groups are included from both sexes with any blunt abdominal trauma mechanism including polytrauma such as road traffic accidents and falling from height.

Exclusion criteria

The following were the exclusion criteria:

(1) Patients with open abdominal wounds.
(2) Patients with diabetes/immunosuppressive states/ serious systemic comorbidities.
(3) Malignant conditions.

Studied parameters

The studied parameters were as follows:

(1) History and clinical examination.
(2) Full blood count, blood glucose, blood urea, and serum creatinine.
(3) Operative findings: viscus perforation, peritoneal content whether bleeding or soiling, and solid organ injury.
(4) Postoperative wound infection and incidence of SSSI and DSSI.
(5) Outcome of wound infection.

Study technique

(1) All the patients admitted in the emergency surgery department who needed emergency laparotomy for blunt abdominal trauma were candidates for the study.
(2) Preoperative investigations were done (to complete the inclusion and exclusion criteria as described).
(3) Intravenous antibiotic was given to all patients at induction of anesthesia (IV ceftriaxone 20 mg/kg and IV metronidazole 7 mg/kg).
(4) At laparotomy, the findings were noted.
(5) Postoperatively the patients were closely monitored for signs of wound infection.
(6) In patients with infected wounds, the discharge was sent for culture sensitivity, and the findings were noted.
(7) Standard practice of wound care was done (with regular dressings) in infected wounds, and the outcome of wound was recorded.
(8) After discharge, the patients were followed up in the outpatient clinic for one month.
(9) A scoring system, which we formulated in the surgery department in the Faculty of medicine at Cairo University in Egypt, was used to assess risk factors for prediction of SSI of the included patients (Tables 1–3).

The study correlated this scoring system for each patient to the incidence of SSI with minimum score =zero and maximum score = 18.

Table 1 Preoperative parameters

Parameter	Score
Clinical status (Preoperative hypotension with systolic BP<90 mmHg)	No 0
	Yes 1
Time elapsed from trauma to surgical intervention	< or = 6 h 0
	>6 h 1
Use of prophylactic antibiotics	Yes 0
	No 1
FAST (intraperitoneal fluid collection)	No 0
	Yes 1
Random blood glucose level	< or = 140 mg/dl 0
	>140 mg/dl 1

Table 2 Intraoperative parameters

Parameter	Score
Intraoperative hypotension (systolic BP less than 90 mmHg)	No 0
	Yes 1
Blood transfusion	No 0
	Yes 1
Surgical duration	< or = 2 h 0
	>2 h 1
Intraoperative findings	Negative exploration 0
	One or more solid organ injury 1 Viscus injury 2
	Combined viscus + solid organ injury 3
Intraperitoneal drain inserted	No 0
	Yes 1
Exteriorized bowel	No 0
	Yes 1
Wound closure with non-absorbable polypropylene	Interrupted sutures 0
	Continuous sutures 1

Table 3 Postoperative parameters

Parameter	Score
ICU admission	No 0
	Yes 1
Feeding status	Enteral 0
	Parenteral 1
Postoperative antibiotics	Yes 0
	No 1
Other postoperative infection like UTI and chest infection.	No 0
	Yes 1

Results

In our study, 30 patients underwent emergency laparotomy for blunt abdominal trauma and were observed for the occurrence of postoperative surgical site infection, with the following results) Tables 4 and 5).

(1) Demographic distribution of population of the study was 66.7% males and 33.3% females.
(2) Each one of the 30 patients was evaluated according to the scoring system mentioned before.
(3) The study showed increased incidence of postoperative SSI in patients with higher risk factor total score (score > 7) and low incidence with scores below that, with significant relation (*P* value < 0.001). (Fig. 1).
(4) Incidence of risk actors:
(5) Relation of each risk factor to the incidence of SSI: (Tables 6–11) showing this relation.
    (a) Preoperative factors.
    (b) Intraoperative factors.
    (c) Postoperative factors.
(6) The study showed a significant relation between the occurrence of SSI and the following factors:
    (a) Preoperative hypotension, with systolic blood pressure < 90 mmHg, as 17 patients (56.667%) developed preoperative hypotension, 6 of them had SSI (100% of established SSI cases), showing significant relation, with *P* value=0.024. (Fig. 2).
    (b) Blood transfusion, as all of the 6 cases who developed SSI are included in the 17 patients (56.67% of all cases) who had blood

Table 4 Variables of age and total score of population under the study

	Mean±SD	Median (IQR)	Maximum: Minimum
Age	25.6±15	24.5 (15:33)	62:4
Total score	6.9±2.4	6.5 (6:7)	15:3

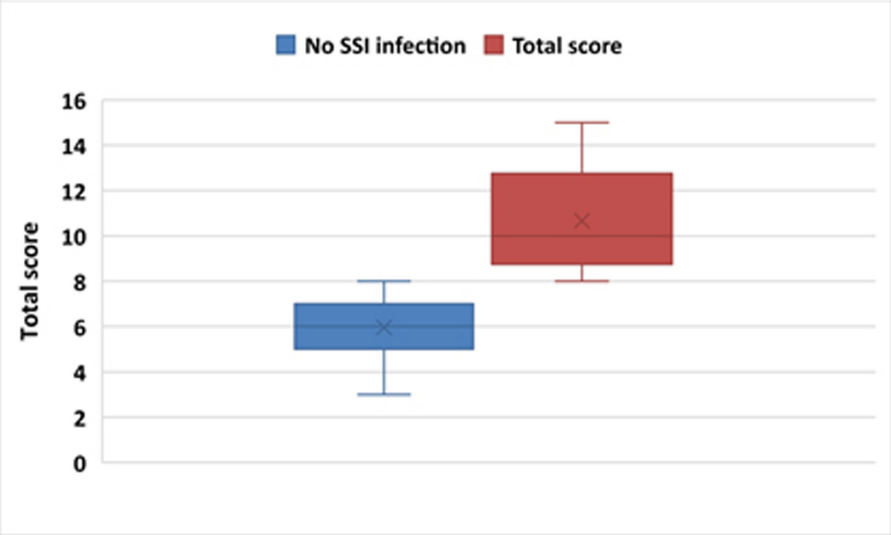
Table 5 Variables in age and total score in relation to SSI

	SSI		
	No	Yes	*P* value
Age			
Mean±SD	23.3±14.3	34.7±15.5	0.089
Median(IQR)	23 (12.5:32)	29.5 (25:52)	NS
Total score			
Mean±SD	6±1.2	10.7±2.5	<0.001
Median(IQR)	6 (5:7)	10 (9:12)	

Table 6 Preoperative risk factors for the development of SSI

Sex	*N* (%)
Male	20 (66.70)
Female	10 (33.30)
Preoperative hypotension	***N* (%)**
No	13 (43.30)
Yes	17 (56.70)
Time to surgery	***N* (%)**
Less than OR equal 6	21 (70.00)
>6	9 (30.00)
Prophylactic antibiotics	***N* (%)**
No	0 (0.00)
Yes	30 (100.00)
FAST	***N* (%)**
No	0 (0.00)
Yes	30 (100.00)
RBS	***N* (%)**
Equal or less than 140	22 (73.30)
More than 140	8 (26.70)

Figure 1



Graph demonstrating the relation between the total risk score and the incidence of SSI.

Table 7 Intraoperative risk factors for the development of SSI

Intraoperative Hypotension	*N* (%)
No	25 (83.30)
Yes	5 (16.70)
Blood transfusion	*N* (%)
No	13 (43.30)
Yes	17 (56.70)
Surgical duration	*N* (%)
< or = 2 h	7 (23.30)
>2 h	23 (76.70)
Intraoperative Finding	*N* (%)
Negative exploration	0 (0.00)
One or more solid organ injury	18 (60.00)
Viscus injury	9 (30.00)
Combined viscus +solid organ injury	3 (10.00)
Intraperitoneal drains	*N* (%)
No	0 (0.00)
Yes	30 (100.00)
Exteriorized bowel	*N* (%)
No	29 (96.70)
Yes	1 (3.30)

Table 8 Post-operative risk factors for the development of SSI

Wound closure	***N* (%)**
Interrupted sutures	29 (96.70)
Continuous sutures	1 (3.30)
Postoperative ICU admission	***N* (%)**
No	24 (80.00)
Yes	6 (20.00)
Feeding status	***N* (%)**
Enteral	19 (63.30)
Parenteral	11 (36.70)
Postoperative antibiotics	***N* (%)**
No	0 (0.00)
Yes	30 (100.00)
Other postoperative Infection	***N* (%)**
No	26 (86.70)
Yes	4 (13.30)
SSI	***N* (%)**
No	24 (80.00)
Yes	6 (20.00)

transfusion, showing significant relation, with *P* value = 0.024. (Fig. 3).

(c) Intraoperative findings with increased incidence of SSI in patients with injured viscus or combined injury (solid organ + viscus) than in patients with only solid organ injury showing significant relation between viscus injury and the occurrence of postoperative SSI, with *P* value=0.003. (Fig. 4).

Postoperative ICU admission, as 4 out of the 6 patient who were admitted in the ICU postoperatively developed SSI (66.7%) showing significant relation with *P* value = 0.007. (Fig. 5).

Table 9 The relation between each preoperative risk factor and SSI

	SSI		
	No	Yes	*P* value
Sex	***N* (%)**	***N* (%)**	
Male	15 (62.5)	5 (83.3)	0.633
Female	9 (37.5)	1 (16.7)	
Preoperative hypotension	***N* (%)**	***N* (%)**	
No	13 (54.2)	0 (0)	0.024
Yes	11 (45.8)	6 (100)	
Time to surgery	***N* (%)**	***N* (%)**	
Less than or equal 6 h	16 (66.7)	5 (83.3)	0.637
>6 h	8 (33.3)	1 (16.7)	
Prophylactic antibiotics	***N* (%)**	***N* (%)**	
Yes	24 (100)	6 (100)	
No	0 (0)	0 (0)	
FAST	***N* (%)**	***N* (%)**	
No	0 (0)	0 (0)	
Yes	24 (100)	6 (100)	
RBS	***N* (%)**	***N* (%)**	
Equal or less than 140	18 (75)	4 (66.7)	0.645
More than 140	6 (25)	2 (33.3)	

(1) Feeding status starting from day 2 postoperatively:

19 patients started early enteral feeding with no subsequent SSI occurrence, whereas 11 patients were only on parenteral nutrition for a longer period, of which 6 patients developed SSI (100% of established SSI cases); this shows a significant relation between the postoperative feeding status and the occurrence of SSI, with *P* value = 0.001 (Fig. 6).

(1) Other postoperative infection as only 2 patients (33.3% of SSI cases) out of the 26 patients without other postoperative infection developed SSI, whereas all of the 4 patients with other postoperative infection developed SSI (66.7%), showing a significant relation, with *P* value =0.001.

(Figure 7).

In the ROC (Receiver Operating Characteristic) curve, the AUC (Area Under Curve) was 0.997, and this means that the total score is excellent in discriminating the patient with SSI and the patient without SSI, and the cutoff point above which the patient had SSI is 7, with sensitivity 100% and specificity 95.83% (Fig. 8 and Tables 12 and 13).

Discussion

In our study, 30 patients who underwent emergency laparotomy for blunt abdominal trauma were observed for the occurrence of SSI, whether developed or not,

Table 10 Relation between each intraoperative risk factor and SSI

	SSI		
Intraoperative Hypotension	No *N* (%)	Yes *N* (%)	No *P* value
No	21 (87.5)	4 (66.7)	0.245
Yes	3 (12.5)	2 (33.3)	
Blood transfusion	***N* (%)**	***N* (%)**	
No	13 (54.2)	0 (0)	0.024
Yes	11 (45.8)	6 (100)	
Surgical duration	***N* (%)**	***N* (%)**	
< or = 2 h	7 (29.2)	0 (0)	0.290
>2 h	17 (70.8)	6 (100)	
Intraoperative Finding	***N* (%)**	***N* (%)**	
One or more solid organ injury	17 (70.8)	1 (16.7)	0.003
Viscus injury	7 (29.2)	2 (33.3)	
Combined viscus +solid organ injury	0 (0)	3 (50)	
Intraperitoneal drains	***N* (%)**	***N* (%)**	
No	0 (0)	0 (0)	
Yes	24 (100)	6 (100)	
Exteriorized bowel	***N* (%)**	***N* (%)**	
No	24 (100)	5 (83.3)	0.2
Yes	0 (0)	1 (16.7)	
Wound closure	***N* (%)**	***N* (%)**	
Interrupted sutures	23 (95.8)	6 (100)	1
Continuous sutures	1 (4.2)	0 (0)	

after proper risk factor assessment with the scoring system that we had formulated in the surgery department in the Faculty of Medicine, Cairo University.

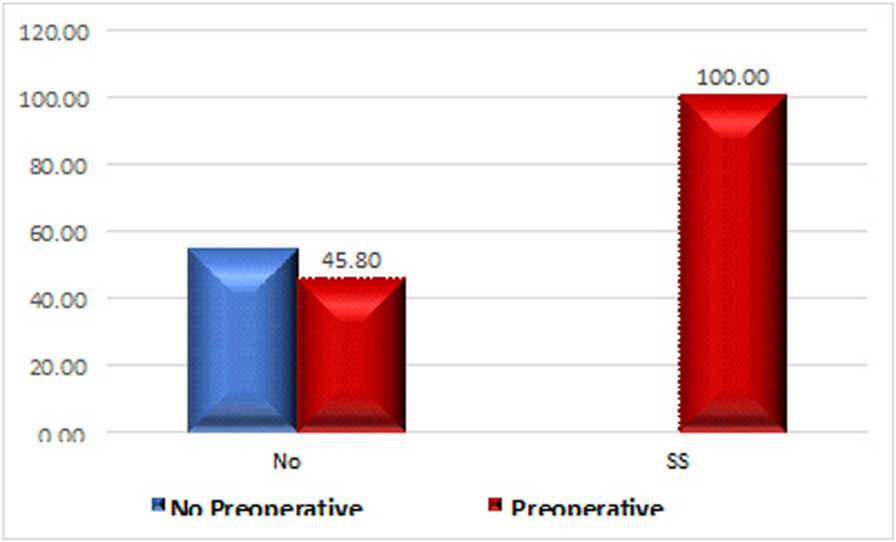
The study showed that there is a significant relation between the incidence of SSI, in the patients under the study, and the following factors:

(1) Preoperative hypotension, with systolic blood pressure <90 mm Hg (*P* value=0.024), as all patients with established SSI had developed preoperative hypotension.
(2) Blood transfusion (*P* value=0.024), as all patients with established SSI had blood transfusion.
(3) Viscus injury (*P* value=0.003), as the incidence of SSI is higher in case of viscus, or viscus + solid organ injury than in case of solid organ(s) injury alone.

Table 11 Relation between each postoperative risk factor and SSI

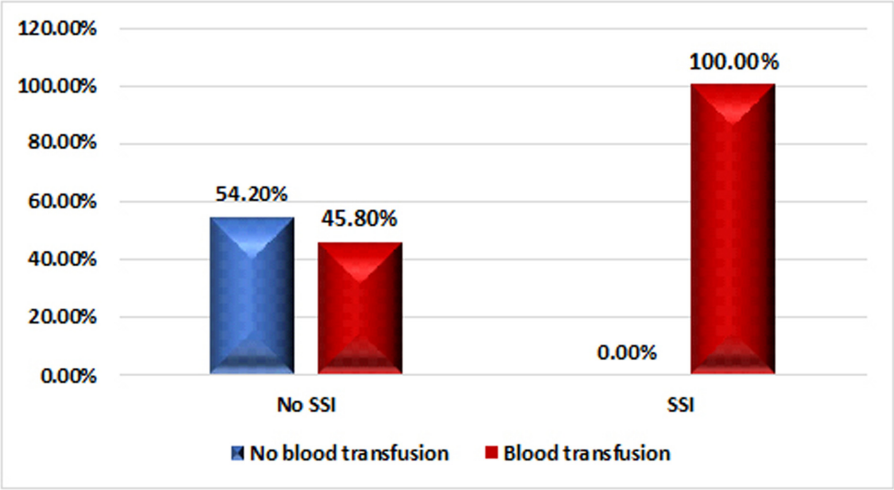
	SSI		
Postoperative ICU admission	No *N* (%)	Yes *N* (%)	*P* value
No	22 (91.7)	2 (33.3)	0.007
Yes	2 (8.3)	4 (66.7)	
Feeding status	***N* (%)**	***N* (%)**	
Enteral	19 (79.2)	0 (0)	0.001
Parenteral	5 (20.8)	6 (100)	
Postoperative Antibiotics	***N* (%)**	***N* (%)**	
Yes	24 (100)	6 (100)	
No	0 (0)	0 (0)	
Other postoperative Infection	**No (%)**	***N* (%)**	
No	24 (100)	2 (33.3)	0.001
Yes	0 (0)	4 (66.7)	

Figure 2



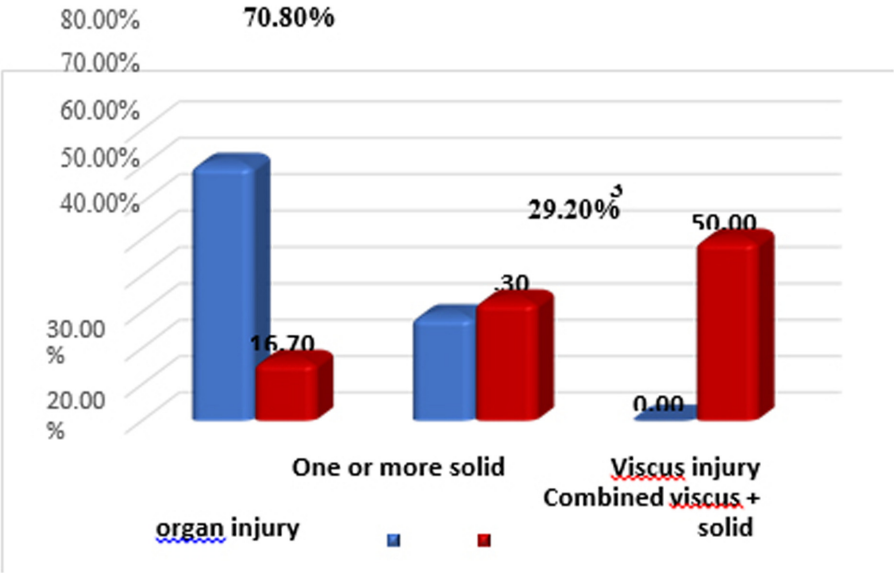
Graph showing the relation between preoperative hypotension as a risk factor and SSI as a result.

Figure 3



Graph showing relation between blood transfusion as a risk factor and SSI as a result.

Figure 4



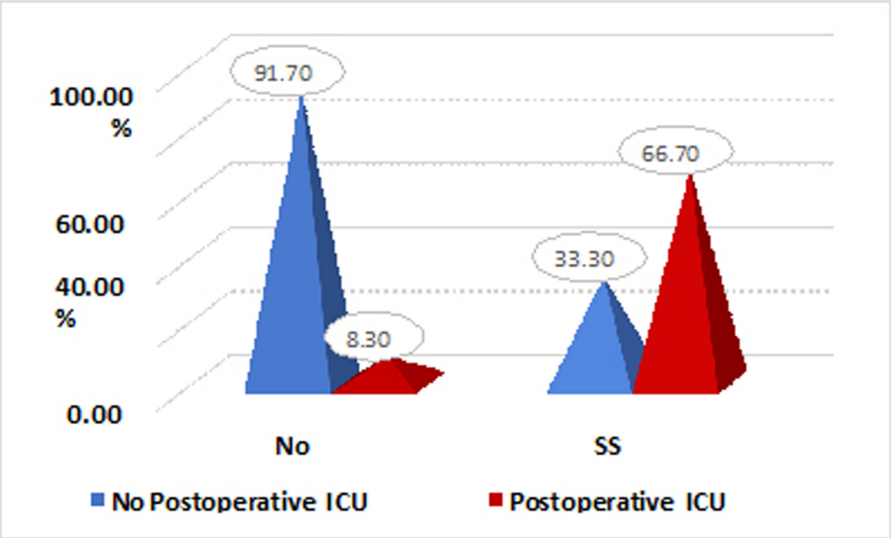
Graph demonstrating the relation between the nature of intra-abdominal organ injury and SSI.

(4) Postoperative ICU admission (*P* value=0.007), with SSI recorded in 66.7% of postoperative ICU admitted cases.
(5) Feeding status from day 2 postoperatively (*P* value=0.001), with 100% of cases with SSI were on parenteral feeding for longer periods than others who started early enteral feeding; 54.5% of parenteral feeding patients developed SSI.
(6) Other postoperative infection (*P* value=0.001), as 66.7% of patients with other postoperative infection developed SSI.
(7) Total risk score with cutoff point >7, at which patient develops SSI (*P* value=0.001).
(8) The study showed that the total incidence of SSI in the group under the study was 20% with only superficial and deep SSI.

All cases with SSI were discharged after proper treatment including regular wound dressing change and adequate antibiotic prescription according to bacterial cultures and antibiotic sensitivity.

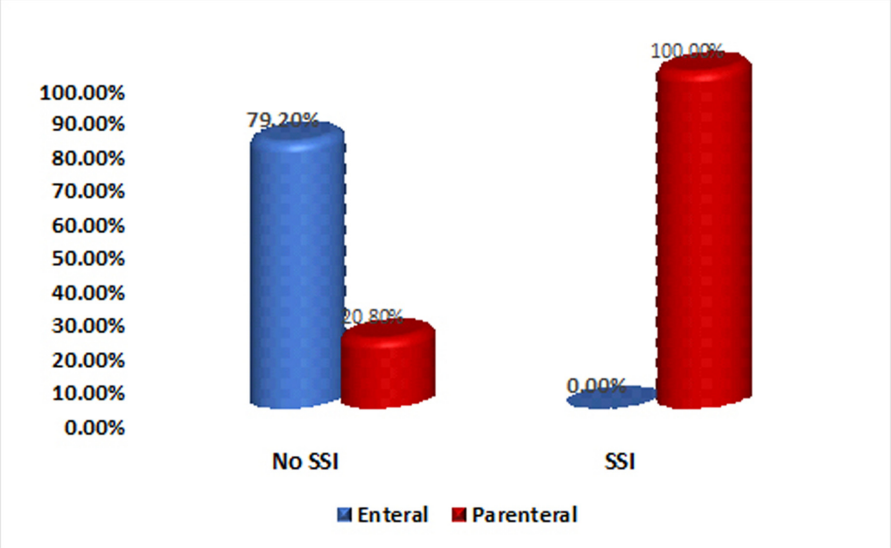
The study concluded that the following measures are important to prevent/minimize incidence of SSI in patients undergoing emergency laparotomy due to blunt injury:

Figure 5



Graph shows relation between postoperative ICU admission and SSI.

Figure 6



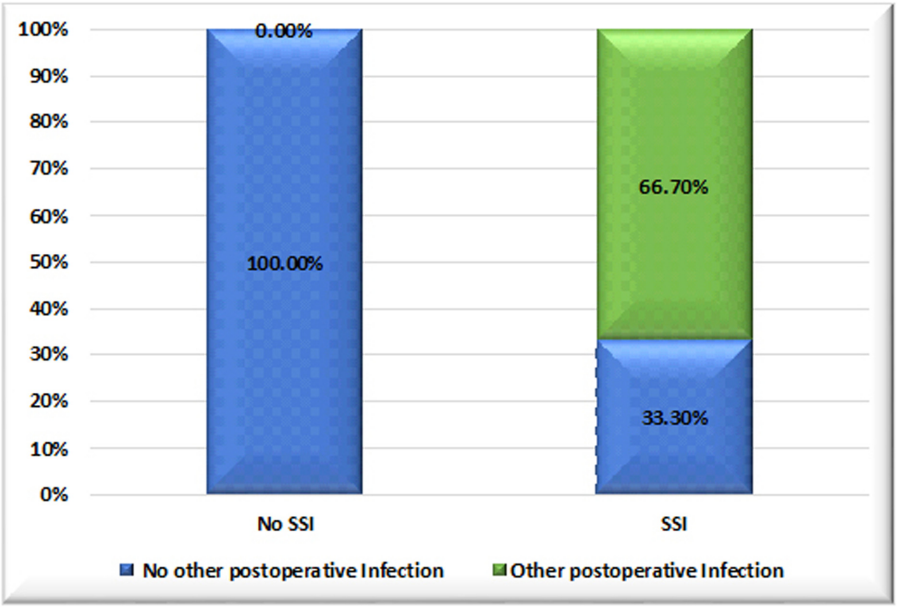
Graph showing relation between postoperative feeding status and SSI.

(1) Early adequate and aggressive trauma patient resuscitation to prevent hypotension and minimize the need for blood transfusion.
(2) Timing of decision for surgical intervention to stop any ongoing hemorrhage (external or internal) to eliminate needs for blood transfusion.
(3) Incision isolation from intra-abdominal contamination in viscus injury as much as possible.
(4) Early enteral feeding whenever possible according to enhanced recovery principles with adequate nutritional support.
(5) Prevention of other postoperative infections such as urinary tract and chest infections by early detection and proper treatment.

Conclusion and summary

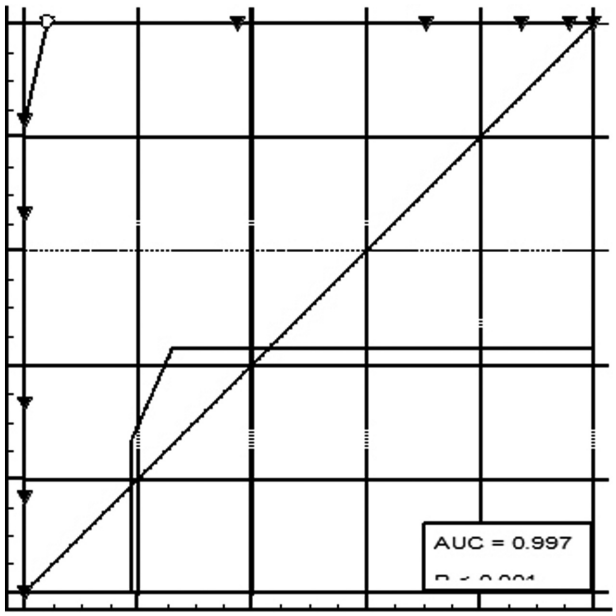
(1) Surgical site infection is one of the commonest postoperative complications that presents health care burden and prolonged postoperative in-hospital patient stay.
(2) Every attempt should be done to prevent SSI, including preoperative, intraoperative, and postoperative measures.
(3) Understanding the anatomy of the abdomen, mechanisms of intra-abdominal organ injury, and the basic microbiology is crucial in competing SSI.

Figure 7



Graph showing relation between the occurrence of other postoperative infection and SSI.

Figure 8



ROC curve showing sensitivity and specificity of the total score to the incidence of SSI.

(4) The risk of developing SSI is multifactorial, and every attempt should be done to minimize risk factors as possible.
(5) Viscus injury especially with intraperitoneal soiling seems to have more rates of postoperative SSI.
(6) Adequate preoperative resuscitation, use of prophylactic antibiotics, shortening surgical duration, prevention of other infections, and keeping good patient's general condition seem to play important role in preventing SSI.

Table 12 AUC= 0.997 according to the above ROC curve

Area under the ROC curve (AUC)	95% CI	*P* value
0.997	0.878–1.000	<0.0001

Table 13 The cutoff point=7 above which the patients had SSI with 100% sensitivity and 95.83% specificity

Cut off point	Sensitivity	95% CI	Specificity	95% CI
>7	100	54.1–100.0	95.83	78.9–99.9

(7) Early detection of SSI is important to achieve rapid and adequate management.
(8) Use of antibiotics should be according to bacterial culture and local hospital guidelines for infection control.

Prevention and early adequate management of post-laparotomy SSI have great and cost-effective outcomes on all aspects of health care.

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Conflicts of interest
There are no conflicts of interest.

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