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Factors responsible for surgical site infections following emergency nontraumatic abdominal operations

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Abstract

Abdominal surgeries are among those operations that are most commonly associated with increased levels of surgical site infection (SSI). The various causes of SSIs are important to know in order to reduce their occurrence.

Objective: In order to establish the host and environmental factors contributing to SSIs in the setting of emergency non-traumatic abdominal operations.

Methods: This descriptive cross-sectional study was carried out at Mymensingh Medical College Hospital, Bangladesh, on 140 patients who were undergoing emergency non-traumatic abdominal operations during the period from August 2009 to July 2010. Registration information of these patients, details of operation, and patient's data after operation were obtained. Swabs from the wound discharge were inoculated to determine which organisms are likely to have caused the infection and their sensitivity to antibiotics were determined.

Results: The overall SSI rate was 17.14%. SSI rates were higher in patients with co-morbidities (40.48% vs 7.14%, $p<0.001$), longer operative times (60% for > 2 hours vs 4.6% for < 1 hour, $p<0.001$), and contaminated/dirty wounds (32.61% vs 4.35% for clean wounds, $p<0.01$). Delayed surgery initiation and midline incisions were associated with increased SSI rates. *E. coli* (45.83%) and *S. aureus* (37.50%) were the most common isolates. All isolates were sensitive to imipenem.

Conclusion: This study found that there are both host-related factors (co-morbidities and nutritional status of patient) and environmental factors (contaminated wound, operative time, and the type of surgical procedures performed) that predispose the emergency abdominal surgery patient to SSI. The common organisms responsible for such presentations are gram-negative organisms, of which *E. coli* is the most frequent isolate. Improving other modifiable risk factors; appropriate use of antibiotics; and maintaining compliance with basic surgical principles of aseptic surgery are important in decreasing SSI. In developing countries, because of uncontrolled growth of resident flora in wounds and tissues, it may be essential to use prophylactic antibiotics to prevent SSIs.

Keywords: SSI, Imipenem, abdominal surgeries, *E. coli*

Introduction

The infection of a wound can be defined as the invasion of organisms through tissues following a breakdown of local and systemic host defences, leading to cellulitis, lymphangitis, abscess and bacteraemia. Surgical site infection (SSI) has always been a major complication of surgery and trauma and has been documented for 4000-5000 years. Galen recognized that localization of infection in wounds, inflicted in the gladiatorial arena, often heralded recovery, particularly after drainage. The understanding of the causes of infection came in the 19th century. Microbes had been seen under microscope, but Koch laid down the first definition of infective disease known as Koch's postulates. Koch's postulates providing the agency of an infective organism: it must be found in considerable numbers in the septic focus, it should be possible to culture it in a pure form from that septic focus and it should be able to produce similar lesions when injected into another host. Louis Pasteur recognized that micro-organisms were responsible for spoiling wine, turning it into vinegar [1]. Surgical Site Infections (SSIs), previously called post-operative wound infections, result from bacterial contamination during or after a surgical procedure. Surgical site infections are the third most common hospital associated infection, accounting for 14-16 per cent of all infections in hospitalized patients.

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Among surgical patients, surgical site infections are the most frequent cause of such infections, accounting for 38 per cent of the total. Despite every effort to maintain asepsis, most surgical wounds are contaminated to some extent. However infection rarely develops if contamination is minimal, if the wound has been made without undue injury, if the subcutaneous tissue is well perfused and well oxygenated and if there is no dead space. The criteria used to define surgical site infections have been standardized and described three different anatomic levels of infection: superficial incisional surgical site infection, deep incisional surgical site infection and organ/space surgical site infection [2]. According to the degree of contamination wounds may be classified as clean, potentially contaminated, contaminated, and dirty. The incidence of infection, morbidity and mortality increases from clean to dirty. The risk of infection is greater in all categories if surgery is performed as an emergency [3]. The risk of wound infection is influenced but not entirely determined by the degree of contamination. Multiple risk factors and perioperative characteristics can increase the likelihood of superficial surgical site infections. Important host factors include – diabetes mellitus, hypoxemia, hypothermia, leucopenia, nicotine, long term use of steroids or immunosuppressive agents, malnutrition, nares contaminated with *Staphylococcus aureus* and poor skin hygiene. Perioperative / environmental factors are operative site shaving, breaks in operative sterile technique, early or delayed initiation of antimicrobial prophylaxis, inadequate intraoperative dosing of antimicrobial prophylaxis, infected or colonized surgical personnel, prolonged hypotension, poor operative room air quality, contaminated operating room instruments or environment and poor wound care postoperatively [2]. Wound infections usually appear between fifth and tenth post-operative day, but they may appear as early as first post-operative day or even years later. The first sign is usually fever, and post-operative fever requires inspection of the wound. The patient may complain of pain at the surgical site. The wound rarely appear severely inflamed, but edema may be obvious because the skin sutures appear tight [2]. Advances in the control of infection in surgery have occurred in many ways, such as, aseptic operating theatre techniques have replaced toxic antiseptic techniques, antibiotics have reduced post-operative infection rates, delayed primary or secondary closure remains useful in contaminated wounds. When enteral feeding is suspended during the per-operative period, and particularly with underlying disease such as immunosuppression, cancer, shock or sepsis bacteria tend to colonize the normally sterile upper gastrointestinal tract. They may then translocate to the mesenteric lymph nodes and cause the release of endotoxin, which further increases the susceptibility to infection and sepsis, through activation of macrophages and pro-inflammatory cytokine release. The use of selective decontamination of the digestive tract (SDD) is based on the prevention of this colonization [1]. According to the sources, infection may be classified into two types, primary and secondary or exogenous. Primary infections are those acquired from community or endogenous source. Secondary or exogenous infections are acquired from operating theatre or the ward or from contamination at or after surgery. According to severity, surgical site infections can be divided into two types, major and minor. Criteria of major SSI are significant quantity of pus, delayed return home and Patients are systemically ill. Minor SSI may discharge pus or infected serous fluid but should not be associated with excessive discomfort, systemic signs or delay in return home [1]. There are various types of localized infections, such as abscess, cellulites, lymphangitis etc. Abscess may follow puncture wound as well as surgery, but can be metastatic in all tissues following bacteraemia. Abscess needs drainage with curettage. Modern imaging techniques may allow guided aspiration. Antibiotics are indicated if the abscess is not localized. Healing by secondary intention is encouraged. Cellulites are nonsuppurative invasive infection of tissues. It is poorly localized in addition to cardinal signs of inflammation. It is usually caused by organisms such as *ß-hemolytic streptococci, staphylococci and C. perfringens.* Tissue destruction, gangrene and ulceration may follow, which are caused by release of proteases. Systemic signs are common, such as SIRS, chills, fever and rigors. These follow the release of organisms, exotoxins and cytokines into the circulation. However, blood cultures are often negative. Lymphangitis presents as painful red streaks in affected lymphatic, often accompanied by painful lymph node groups in the related drainage area [1].

Systemic inflammatory response syndrome (SIRS) can be defined as, presence of any two of: hyperthermia (>38 °C) or hypothermia (<36° C), tachycardia (>90 min^{-1}, no ß-blockers) or tachypnea (>20 min^{-1}) and white cell count $>12\times 10^9\ \text{l}^{-1}$ or $<4 \times 10^9\ \text{l}^{-1}$(Williams *et al.* 2008). Sepsis is defined as the systemic manifestation of SIRS, with a documented infection. Multiple organ dysfunction syndrome (MODS) is the effect that the infection produces systemically. Multiple system organ failure (MSOF) is the end-stage of uncontrolled MODS [1]. Specific wound infections such as gas gangrene, tetanus and synergistic spreading gangrene are serious infections. Gas and smell are characteristics of gas gangrene that is caused by *Clostridium perfringens.* Immunocompromised patients are most at risk. Antibiotic prophylaxis is essential when performing amputation to remove dead tissue. Tetanus caused by *clostridium tetani*, can develop following implantation of the organisms into tissues or a wound. The spores are wide spread in the soil and manure. Signs and symptoms are mediated by release of exotoxin tetanospasmin. Prophylaxis with tetanus toxoid is the best preventive treatment. The use of anti-toxin using human immunoglobulin ought to be considered in both at risk and established infection. Synergistic spreading gangrene / Sub dermal gangrene / Necrotizing fasciitis is caused by a mixed pattern of organisms such as, *Coliforms*, *Staphylococci*, *Bacteroides* spp., *Anaerobic streptococci* and *Peptostreptococci* have all been implicated, acting in synergy. When occurs in the abdominal wall, known as Meleney's synergistic hospital gangrene and when occurs in the scrotum it is known as Fournier's gangrene [1]. The use of antibiotic prophylaxis before surgery has evolved greatly in the last twenty years. It is generally recommended in elective clean surgical procedures using a foreign body and in clean-contaminated procedures that a single dose of cephalosporin, such as cefazolin, be administered intravenously by anesthesia personnel in the operative suit just before incision. Additional doses are generally recommended only when the operation lasts for longer than two to three hours [4]. Surgical site infection is the most important cause of morbidity and mortality in the post-operative patients, but it is preventable in most of the cases if proper assessment and appropriate measures are taken by the surgeons, nursing staffs, patients and others in the perioperative period.

Objectives

General Objectives

To determine the factors responsible for surgical site infections following emergency non-traumatic abdominal operations, which will be helpful in reducing the rate of surgical site infection

Specific Objectives

- To determine the host factors responsible for surgical site infections.
- To detect the environmental factors contributing to surgical site infections following emergency nontraumatic abdominal operations.
- To identify the microorganisms involved in surgical site infections.

Materials and Methods

This was a descriptive cross-sectional study performed at the Surgical Unit, Mymensingh Medical College Hospital, Mymensingh. Ethical clearance for the study protocol was obtained from the Thesis and Ethical Committee of Mymensingh Medical College and Hospital. The study was conducted for one year: August 1, 2009, through July 31, 2010. The total number of patients enrolled in the study was 140 purposively sampled patients. This approach made it appropriate to sample only those patients that were appropriate for the research in line with the study goals.

- **Inclusion Criteria:** Patients undergoing emergency non-traumatic abdominal operations in Surgery Unit-1 at Mymensingh Medical College Hospital.
- **Exclusion Criteria:** Patients with traumatic injuries were excluded.

Study Procedure: Consequently, purposive non-random sampling was used. To all patients presenting with acute abdomen, a brief history and physical examination were done as an initial assessment on admission. Emergency and fairly urgent essential investigations were performed to allow appropriate management. Only those patients who fulfilled the inclusion criteria were offered the chance to participate in the study, and written patient or, if necessary, legal representative consent was provided. Case histories of patients who contracted SSI were taken in order to pinpoint risk factors for surgeries. A complete physical check-up and some necessary investigations were done. Risk factors concerning SSI before the operation were identified, and surgery was performed in an aseptic manner. The information regarding the operative procedure and factors related to the operation were noted on data collection forms. After the surgeries, patients were followed up daily, and any clinical features suggestive of infection were looked for. Pus collections, if found, were cultured, and antibiotics were further tailored on the basis of sensitivities.

Data Collection and Analysis: Data were gathered using a structured questionnaire through direct interviews with patients or their guardians. Data were compiled and analyzed both manually and using SPSS software, with results presented in tables and figures.

Results

This descriptive, cross-sectional study was carried out to determine factors responsible for surgical site infections following emergency non-traumatic abdominal operations that will be helpful in reducing rate of surgical site infections. One hundred and forty patients with emergency nontraumatic abdominal operations were selected purposively from Surgery unit-1 of Mymensingh Medical College and Hospital during the period of 1 August, 2009 to 31 July, 2010. All cases were evaluated clinically. Only essential investigations necessary for diagnosis and preoperative assessment were carried out before operations. Postoperatively swab was sent for culture and sensitivity test in every cases with discharge from the wound or collection of pus anywhere in the abdominal area. The patients of both sexes and different ages were included in the study.

Table 1: Age distribution of the patients

Age in years	Number of patients	Percentage (%)
10-19	31	22.14
20-29	30	21.42
30-39	30	21.42
40-49	34	24.28
50-59	9	6.43
60-69	6	4.29
Total	140	100.00

Mean ± SD = (32.93± 3.79) years

It was observed that age of 140 patients ranged from 13-65 years. Most of the patients (89.29 %) were in between 10-49 years.

Table 2: Surgical Site Infection (SSI) distribution by different age groups

Age in years	SSI status		Total
	Yes	No	
10-19	5(16.13)	26(83.87)	31(100.00)
20-29	2(6.67)	28(93.33)	30(100.00)
30-39	5(16.67)	25(83.33)	30(100.00)
40-49	9(26.47)	25(73.53)	34(100.00)
50-59	2(22.23)	7(77.77)	9(100.00)
60-69	1(16.67)	5(83.33)	6(100.00)
Total	24(17.14)	116(82.86)	140(100.00)

* Figures within parentheses indicate percentage.

$\chi^2 = 4.596$; $p>0.05$, DF = 5

It was observed that rate of SSI in different age groups were as follows: 5(16.13%) in the 10-19 years, 2(6.67%) in the 20-29 years, 5(16.67%) in the 30-39 years, 9(26.47%) in the 40-49 years, 2(22.23%) in the 50-59 years and 1(16.67%) in the 60-69 years. It was highest 26.47% (9 among 34) in the 40-49 years age group. However, these differences were not statistically significant.

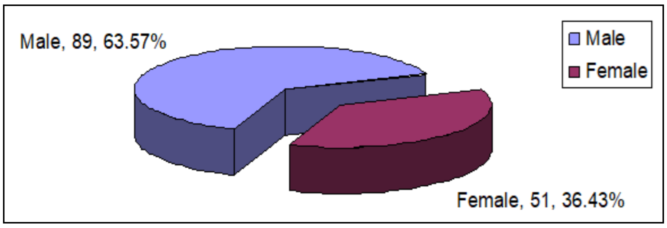

Fig 1: Pie diagram showing distribution of the patients by se.

Table 3: Surgical Site Infection (SSI) distribution by Sex

Sex	**SSI status**		**Total**
	Yes	No	
Male	16(17.98)	73(82.02)	89(100 .00)
Female	8(15.69)	43(84.31)	51(100.00)
Total	24(17.14)	116(82.86)	140(100 .00)

$\chi^2 = 0.145$; $p>0.05$
DF=1

Regarding sex distribution of SSI, it was observed that among 89 male patients 16(17.98%) developed SSI, whereas among 51 female patients 8(15.69%) developed SSI. Rate of SSI was slightly higher in males. Sex difference in SSI was not statistically significant ($p>0.05$).

Table 4: SSI distribution based on different educational status

Educational status	**SSI status**		**Total**
	Yes	**No**	
Illiterates	6(24.00)	19(76. 00)	25(100.00)
Primary	2(22.22)	7(77.78)	9(100.00)
Secondary	6(17.14)	29(82.86)	35(100.00)
SSC	5(18.52)	22(81.48)	27(100.00)
HSC	2(11.11)	16(88.89)	18(100.00)
Graduation or above	3(11.53)	23(88.47)	26(100.00)
Total	24(17.14)	116(82.86)	140(100.00)

$\chi^2 = 2.33$; $p>0.05$
DF = 5

It was revealed that among 140 patients, 24(17.14%) developed surgical site infection (SSI). Overall rate of SSI was 17.14%. Regarding relationship between educational status and SSI it was observed that rate of SSI was highest 6 among 25(24.00%) in illiterates. It was 2 among 9(22.22%) in primary educated group, 6 among 35(17.14%) in secondary education group, 5 among 27(18.52%) in SSC passed, 2 among 18(11.11%) in HSC passed and only 3 among 26(11.53%) in graduation or above group. It was observed that rate of SSI decreased with rise in level of education. However, association between level of education and rate of SSI was statistically insignificant ($p>0.05$).

Table 5: Number of operations, SSIs and SSI rate (%) by category

Types of operations	**Status of SSI**		**Total**
	Yes	**No**	
Appendicectomy	5(8.33)	55(91.67)	60(100.00)
Adhesiolysis or resection and anastomosis	3(10.00)	27(90.00)	30(100.00)
Repair of ileal perforation / Ileostomy and thorough peritoneal toileting	8(42.10)	11(57.89)	19(100.00)
Repair of duodenal ulcer perforation and thorough peritoneal toileting	3(20.00)	12(80.00)	15(100.00)
Appendicectomy with peritoneal toileting	4(33.33)	8(66.66)	12(100.00)
Resection of Volvulus of sigmoid colon and primary anastomosis/ Hartmans procedure	1(50.00)	1(50.00)	2(100.00)
Herniotomy and herniorrhaphy	_	2(100.00)	2(100.00)
Total	24(17.14)	116(82.86)	140(100.00)

Table 6: SSI distribution based on category of surgeons

Category of surgeons	**Status of SSI**		**Total**
	Yes	**No**	
Assistant Registrars and IMOs	19(19.19)	80(80.81)	99(100.00)
Registrar	3(15.00)	17(85.00)	20(100.00)
Resident surgeon	2(13.33)	13(86.67)	15(100.00)
Professor	--	6(100.00)	6(100.00)
Total	24(17.14)	116(82.86)	140(100.00)

$\chi^2 = 1.638$; $p>0.05$
DF=3

Junior surgeons like assistant registrars or indoor medical officers operated upon 99 cases, out of which 19(19.19%) got infected; whereas, rate of SSI was relatively lower when operated by experienced surgeons, such as registrar 3 among 20(15.00%) and resident surgeon 2 among 15(13.33%). No SSI occurred in 6 cases done by professor. So, there is a trend towards decreased rate of SSI with increase in experience of the operating surgeon, although the difference was not statistically significant ($p>0.05$).

Table 7: SSI distribution based on different types of incision

Type of Incisions	**Status of SSI**		**Total**
	Yes	**No**	
Extended lower midline	1(50.00)	1(50.00)	2(100.00)
Mid midline	8(42.11)	11(57.89)	19(100.00)
Lower right para- median	4(33.33%)	8(66.66)	12(100.00)
Rutherford Morison	3(20.00)	12(80.00)	15(100.00)
Upper midline	2(13.33)	13(86.66)	15(100.00)
Extended upper midline	4(13.33)	26(86.66)	30(100.00)
Grid iron	2(05.00)	38(95.00)	40(100.00)
Lenz	0(00.00)	5(100.00)	5(100.00)
Inguinal	0(00.00)	2(100.00)	2(100.00)
Total	24(17.14)	116(82.86)	140(100.00)

Rate of SSI was highest, 1 in 2(50.00%) operations done through extended lower midline incision, whereas rate of SSI was 8 among 19(42.11%) in mid midline, 4 among 12(33.33%) in lower right para-median, 3 among 15(20.00%) in Rutherford Morison, 2 among 15(13.33**%**) in upper midline, 4 among 30(13.33%) in extended upper midline and 2 among 40(5.00%) in grid iron incisions. No infection occurred in 5 operations done through Lenz incision and 2 operations through inguinal incisions.

Table 8: SSI distribution based on delay to initiate operation

Delay to initiate operations in hours	**SSI status**		**Total**
	Yes	**No**	
< 6	1(9.09)	10(90.91)	11(100.00)
6-12	2(10.53)	17(89.47)	19(100.00)
12 -24	5(15.63)	27(84.37)	32(100.00)
24-48	7(18.42)	31(81.58)	38(100.00)
48 – 72	6(19.35)	25(80.65)	31(100.00)
> 72	3(33.33)	6(66.66)	9(100.00)
Total	24(17.14)	116(82.86)	140(100.00)

With regard to association between delay to initiate operation and rate of SSI it was observed that the surgical site infection rates were 9.09%, 10.53%, 15.63%, 18.42%, 19.35% and 33.33% when operations were initiated <6, 6-12, 12-24, 24-48, 48-72 and >72 hours later respectively. The rate of infection increased as the time lapse between appearance of first symptom and initiation of operation were increased.

Table 9: SSI distribution based on duration of operations

Duration of operation	**SSI status**		**Total**
	Yes	**No**	
Less than 1 hour	4(4.60)	83(95.40)	87(100.00)
1 to 2 hours	14(32.55)	29(67.45)	43(100.00)
More than 2 hours	6(60.00)	04(40.00)	10(100.00)
Total	24(17.14)	116(82.86)	140(100.00)

$\chi^2 = 29.79$; $p<0.001$
DF = 2

With respect to duration of operation and percentage of SSI it was observed that 87 operations were done requiring less then one (< 1) hour in each case; SSI developed in only 4(4.60%) of these cases. Whereas, 43 operations were completed between 1-2 hours each; among them 14(32.55%) developed SSI. It was observed that, 10 operations required more than 2 hours each; among these SSI occurred in 6(60.00%) cases. The rate of SSI increased with prolongation of duration of operation. The difference in percentage of SSI with duration of operation was statistically significant (*p*<0.001). In relation to appearance of infection on postoperative days it was observed that most of the infections (91.66%) were started between 4th and 8th post-operative days (POD) and it was highest 8(33.33%) on 5th POD. Among a total of twenty-four patients with surgical site infections, in only one patient (4.17%) features of infection first appeared on 3rd POD and it was three (12.50%) on 4th, eight (33.33%) on 5th, six(25%) on 6th, three (12.50%) on 7th, two (8.33%) on 8th and one(4.17%) on 9th POD.

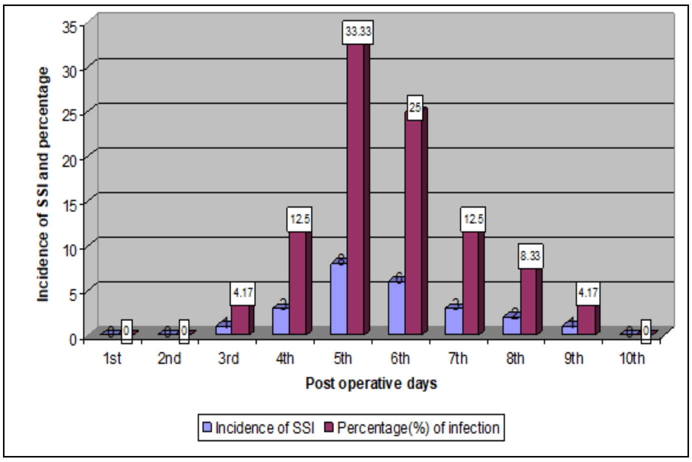

Fig 2: Bar diagram showing incidence of SSI after emergency nontraumatic abdominal surgery in different post-operative days

Table 10: SSI distribution based on types of wounds by the degree of contamination

Types of wounds	SSI status		Total
	Yes	No	
Clean	1(4.35)	22(95.65)	23(100.00)
Clean contaminated	5(8.33)	55(91.67)	60(100.00)
Contaminated	3(27.27)	8(72.73)	11(100.00)
Dirty	15(32.61)	31(67.39)	46(100.00)
Total	24(17.14)	116(82.86)	140(100.00)

$\chi^2 = 14.49$; $p<0.01$
DF = 3

Table 11: SSI distribution based on Co-morbidity status

Co-morbidity status	SSI status		Total
	Yes	No	
With co-morbidity	17(40.48)	25(59.52)	42(100.00)
Without Co-morbidity	7 (7.14)	91(92.86)	98(100.00)
Total	24(17.14)	116(82.86)	140(100.00)

$\chi^2 = 22.98$; $p<0.001$
DF = 1

In relation to different types of wounds, by the degree of contamination, it was observed that among 140 cases 23 were clean wounds; SSI developed only in 1(4.35%) of these clean cases. There were 60 clean contaminated cases, among them SSI occurred in 5(8.33%); whereas SSI developed in 3 among 11(27.27%) contaminated wounds. The rate of SSI was as high as 15 among 46(32.61%) dirty cases. The difference had high statistical significance (*p*<0.01). It can be assumed that the infection rate increased with that of degree of wound contamination**.**

In relation to co-morbidity, it was observed that 42 patients had co-morbid disorders associated with the main surgical disease and 98 patients had no co-morbid disorder. Among the patients with co-morbid disorders 17(40.48%) developed surgical site infection (SSI), whereas, in the patients without any co-morbidity only 7(7.14%) developed SSI. The difference of rate of infection between these two groups was very obvious. It was clear that associated co-morbid disorders played a vital role as a host related risk factor for SSI. Moreover, the difference was statistically highly significant (*p*<0.001).

Table 12: Surgical site infection distribution based on presence of different co-morbidities

Types of co-morbidity	SSI status		Total
	Yes	No	
Malnutrition	11(45.12)	13(54.17)	24(100.00)
COPD	2(28.57)	5(71.43)	7(100.00)
Diabetes Mellitus	2(33.33)	4(66.67)	6(100.00)
Obesity	1(33.33)	2(66.67)	3(100.00)
Medical Jaundice	1(50.00)	1(50.00)	2(100.00)
Total	17(40.48)	25(59.52)	42(100.00)

In 24 patients with malnutrition 11(45.12%) developed SSI, whereas among 7 patients with COPD 2(28.57%) developed SSI. 6 persons were diabetic, among them 2(33.33%) suffered from SSI. 3 persons were obese, 1 of them (33.33%) developed SSI, whereas, 1of 2(50.00%) persons suffering from medical jaundice developed SSI.

Among 140 patients, 25 developed some type of discharge from the wounds / collection of pus anywhere in the abdominal area. In eleven (44.00%) cases there were mudy thin odourless pus, in nine (36.00%) cases there were thick creamy pus, in two (8.00%) cases there were bluish green pus, in another two(8.00%) cases there were yellow fishy odoured pus and in one(4.00%) case there were serosanguinous discharge

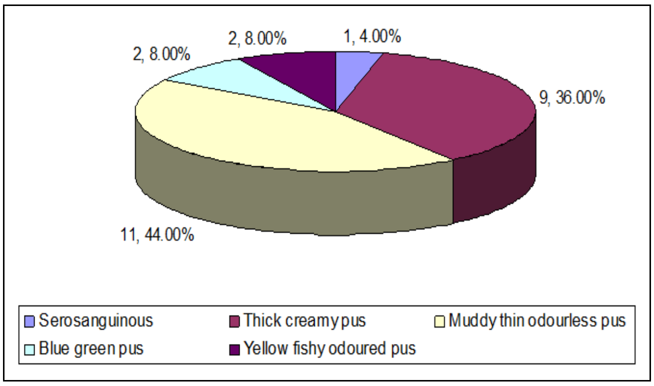

Fig 3: Frequency of various types of discharge/ pus from 25 wounds

Table 13: Organisms isolated and cultured from different types of discharge from wound /collection of pus

Character of discharge/pus	Frequency	Organisms isolated
Thin muddy odourless pus	11	*Escherischia coli*
Thick creamy pus	9	*Staphylococcus aureus*
Yellow fishy odoured pus	2	*Klebsiella pneumonea.*
Blue green pus	2	*Pseudomonus aeruginosa*
Serosanguinous discharge	1	No growth
Total	25	

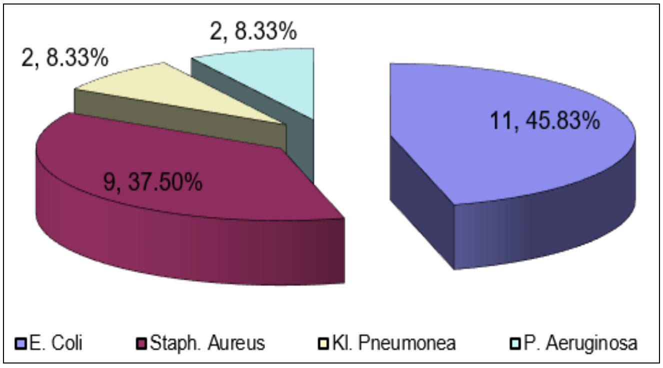

Fig 4: Pie diagram showing bacteria isolated from 24 surgical site infections

Table 14: Sensitivity pattern of the cultured micro-organisms to various antibiotics

Name of micro-organisms (number of cases)	**Antibiotics and their sensitivity in percentage (number of cases)**						
	Ciprofloxacin	**Cephradin**	**Cotrimoxazole**	**Flucloxacin**	**Nitrofurantoin**	**Ceftriaxone**	**Imipenem**
Escherischia coli (11)	45.45(5)	54.54(6)	45.45(5)	-	9.09(1)	72.72(8)	100(11)
Staphylococcus Aureus (9)	44.45 (4)	44.45(4)	-	55.55(5)	-	88.9(8)	100(9)
Klebsiella pneumoniae (2)	-	50(1)	50(1)	-	-	100(2)	100(2)
Pseudomonus aeruginosa (2)	50(1)	_	_	_	50(1)	100(2)	100(2)

Twenty-five samples of discharge/ pus from the wounds or peritoneal cavity were sent for culture and sensitivity test. Among them causative pathogens were detected in twenty-four cases. *Escherischia coli* was found in 11cases with thin mudy odourless pus, *Staphylococcus aureus* in 9 cases with thick creamy pus, *Klebsiella* in 2 cases with yellow fishy odoured pus, *Pseudomonas aeruginosa* in 2 cases with bluish green pus and no growth was detected in 1 case with serosanguinous discharge. *E. coli* were found as the commonest organism (11 among 24 cases) causing 45.83% of the surgical site infections. *Staph. Aureus* were the second most common organism (9 among 24 cases) causing 37.50% of the infections. Each of *klebsiella* and *pseudomonas* were causing 8.33% of the surgical site infections (found in 2 cases among 24 SSI).

Escherischia coli were sensitive to Ciprofloxacin (45.45% cases), Cephradin (54.54% cases), Cotrimoxazole (45.45% cases), Nitrofurantoin (9.09% cases), Ceftriaxone (72.72% cases) and Imipenem (100% cases). All the cases of *E. coli* were resistant to flucloxacillin. Staphylococcus aureus were sensitive to Ciprofloxacin (44.45% cases), Cephradin (44.45% cases), Flucloxacin (55.55% cases), Ceftriaxone (88.9% cases) and Imipenem (100% cases). But, all the cases of Staph. Aureus were resistant to Cotrimoxazole and Nitrofurantoin. *Klebsiella pneumoniae* were sensitive to Cephradin and Cotrimoxazole in 50 per cent cases each and to Ceftriaxone and Imipenem in all (100 per cent) cases. But, all the cases of Kl. Pneumoniae were resistant to Ciprofloxacin, Flucloxacillin and Nitrofurantoin. Fifty (50) percent cases of *Pseudomonus aeruginosa* were sensitive to Ciprofloxacin and Nitrofurantoin, and all the cases of *P. aeruginosa* (100%) sensitive to Ceftriaxone and Imipenem. All of them (100%) were resistant to Cephradin, Cotrimoxazole and Flucloxacillin. All (100%) the organisms isolated were sensitive to Imipenem.

Fig 5: Major wound infection

Fig. 6: Minor wound infection

Discussion

This descriptive, cross-sectional study was conducted among 140 purposively selected patients with emergency non-traumatic abdominal operations conducted in surgery unit-1 of Mymensingh Medical College Hospital, Mymensingh, from August 1, 2009 to July 31, 2010. The study was carried out with a view to determine the factors responsible for surgical site infections (SSI) following emergency non-traumatic abdominal operation which will be helpful in reducing the rate of surgical site infection in the near future. Age of 140 patients ranged from 13-65 years. Most of the patients (125, 89.29%) were in between 10-49 years; with mean age 32.93 years and standard deviation 3.79 years (Table I). In a similar study conducted in an Iranian teaching hospital average age of the patients was 46.70 years (Razavi *et al.* 2005) [5]. Average age of the patients in the Iranian study was much higher than the present study.

It was revealed that among 140 patients 24(17.14%) developed surgical site infection (SSI). Overall rate of SSI was 17.14% (Table II). This finding is consistent with the finding of Razavi *et al.* [5] where they found 139 patients among 802 (17.40%) suffered from SSI (Razavi *et al.* 2005) [5]. The overall SSI rate of present study was consistent with findings of study carried out by Renvall *et al.* [6], in which SSI rate in acute surgery was 12.4 per cent (Renvall *et al.* 1980). [6] It was observed that rate of SSI in different age groups was 16.13% in the 10-19 years, 6.67% in the 20-29 years, 16.67% in the 30-39 years, 26.47% in the 40-49 years, 22.23% in the 50-59 years and 20.00% in the 60-69 years. It was highest 26.47% (9 among 34) in the 40-49 years age group (Table II). This finding is inconsistent with the findings of an Iranian study where they showed the rate of SSI 3.70% in < 25 years age group, 18.10% in 25-65 years age group and 25.20% in > 65 years age group (p<0.001), (Razavi *et al.* 2005) [5]. Inconsistency may be due to small number of old aged population in my study. Regarding sex distribution of the patients, among the total 140 cases 89(63.57%) were male and 51(36.43%) were female. Male-female ratio was 1.74: 1 (Figure1). So, it can be assumed that males are more commonly affected by acute abdominal conditions requiring surgery. Rate of SSI in males were 17.98%, whereas among females it was 15.69% (Table III). Rate of SSI was slightly higher in males, which was not statistically significant. This finding is consistent with that of Razavi *et al.* [5] where they could not find any significant correlation between sex and SSI. Moreover, rate of SSI in males were 19.6%, whereas in females it was 15.1% (p<0.093). So, SSI is not correlated with sex (Razavi *et al.* 2005) [5].

It was observed that host factors like type of disease, presence/absence of co-morbidity and types of co-morbidity and other factors like seniority of surgeon, delay to initiate operation and duration of surgery were associated with the rate of surgical site infection. Regarding educational status, it was observed that rate of SSI was highest, 6 among 25(24.00%), in illiterates. It was 2 among 9(22.22%) in primary educated group, 6 among 35(17.14%) in secondary education group, 5 among 27(18.52%) in SSC passed, 2 among 18(11.11%) in HSC passed and only 3 among 26(11.53%) in graduation or above group (Table IV). It was observed that rate of SSI decreased with rise in level of education. However, the difference of rate of SSI among different groups of patients according to level of education was not statistically significant (p>0.05). Out of 140 patients with emergency nontraumatic abdominal operations, rate of SSI in different operations were as follows: 5 among 60(8.33%) acute appendicitis cases, 3 among 30(10.00%) small intestinal obstruction, 8 among 19(42.10%) ileal perforation, 3 among 15(20.00%) duodenal ulcer perforation, 4 among 12(33.33%) burst appendix, 1 between 2(50.00%) sigmoid volvulus and no SSI occurred in 2 obstructed inguinal hernia cases. The highest rate of infection (50.00%) was in volvulus cases and lowest in obstructed hernia operations (Table V). These findings were consistant with the result of Surgical Site Infection Survillance (SSIS) for general surgery which was published as Wexford General Hospital Surgical Site Infection (SSI) data report in 2009 showing number of SSI and rate of SSI (%) by category of operations. They done 132 appendicectomy, among them SSI occurred in 7(5.3%) cases. SSI occurred in 10(19.2%) cases among 52 Colonic surgeries, 4(23.5%) cases among 17 Small bowel surgery and 5(26.3%) cases among 19 Laparotomies. No SSI was reported among 82 herniorrhaphy cases (Surgical Site Infection Survillance for general surgery 2009) [7]. Junior surgeons like assistant registrars or indoor medical officers operated upon 99 cases, out of which 19(19.19%) got infected; whereas, rate of SSI was relatively lower when operated by experienced surgeons, such as registrar 3 among 20(15.00%) and resident surgeon 2 among 15(13.33%). No SSI occurred in 6 cases done by professor. So, the rate of SSI decreased with the increase in experience of the operating surgeon, although the difference was not statistically significant (p>0.05), (Table VI). These findings are consistent with the findings of study carried out by Paul in 2004 [8], where rate of SSI in operations done by Assistant Registrars and IMOs was 18.33% whereas for registrar it was 12.50% and for professor it was nil. However, assistant registrars and IMOs dealt with the most contaminated and dirty cases. This fact is due to the experienced surgeon’s meticulous surgical technique (Paul 2004) [8]. Regarding incision-wise infection rate, rate of SSI was highest, 1 in 2(50.00%) operations done through extended lower midline incision, whereas rate of SSI was 8 among 19(42.11%) in mid midline, 4 among 12(33.33%) in lower right para-median, 3 among 15(20.00%) in Rutherford Morison, 2 among 15(13.33%) in upper midline, 4 among 30(13.33%) in extended upper midline and 2 among 40(5.00%) in grid iron incisions. No infection occurred in 5 operations done through Lenz incision and 2 operations through inguinal incisions (Table VII). In present study infection rate was higher in midline incisions that may be attributed to less vascularity of the Linea Alba and most contaminated and dirty cases were operated through these incisions. The findings were consistent with the findings of study carried out by Paul in 2004 [8], where the infection rate was 50.00 per cent for Rutherford Morison, 25 per cent for each of right para median and extended midline, 18.18 per cent for upper midline, 9.38 per cent for grid iron incision and nil for inguinal incision (Paul 2004) [8]. With regard to delay to initiate operation and rate of SSI, it was observed that the surgical site infection rate was 9.09%, 10.53%, 15.63%, 18.42%, 19.35% and 33.33% when operation was initiated < 6, 6-12, 12-24, 24-48, 48-72 and > 72 hours later respectively. The rate of SSI increased as the time lapse between first manifestation of symptoms and initiation of operation prolonged (Table VIII). This is similar to the findings of Huda M.N. [9] who conducted a study in Dhaka Medical College in 2005. In that study SSI rate was 15.25%, 21.73%, 27.27%, 40% and 50% respectively when operations were done 6, 12, 24, 48, and 72 hours later (Huda 2005) [9]. This findings is also consistant with the findings of a study conducted in a Peruvian hospital; in which patients with SSI had a longer hospital stay than did non-infected patients (14.0 Vs 6.1 days, p<0.001) it is because prolonged preoperative hospital stay increases SSI rate and occurrence of SSI causes prolonged postoperative stay (Hernandez *et al.* 2005) [10]. With respect to duration of operation and percentage of SSI it was observed that the infection rate varies with duration of operation. It was only 4.6% when the duration of operation was less than one hour. The rate rises with the prolongation of operation. Infection rate was 32.55% when the duration of operation was between one and two hours. The infection rate was as high as 60.00 per cent when duration of operation was more than two hours (Table IX). The rate of SSI increased statistically very significantly with that of duration of operation (p<0.001). It may be due to the prolonged exposure of the wound to the environment leading to more chance to inoculation of micro-organisms. These findings are consistent with the findings of a study conducted in the Imam Khamenei Hospital, Tehran, where the authors comment, “the duration of surgical operation also proved to be a significant factor: only 3% of operations lasting 30 minutes or less led to infection, while for operations lasting more than 6 hours this rate leapt to 18%” (Razavi *et al.* 2005) [5]. In relation to appearance of infection by features like fever, excessive pain, tenderness or discharge from the wound on postoperative days it was observed that most of the infections were started between 4th and 8th post-operative days(PODs) and it was highest (33.33%) on 5th POD. Among a total of twenty-four patients with surgical site infection, in only one patient (4.17%) features of infection first appeared on 3rd POD and it was three (12.50%), eight (33.33%), six(25%), three(12.50%), two(8.33%) and one(4.17%) persons who presents with features of infection on 4th, 5th, 6th, 7th, 8th and 9th POD respectively. No infection started on 1st, 2nd and 10th POD. In relation to different types of wounds, by the degree of contamination, it was observed that among 140 cases 23 were clean wounds, SSI developed only in 1(4.35%) of these clean cases. There were 60 clean contaminated cases, among them SSI occurred in 5(8.33%); whereas SSI developed in 3 among 11(27.27%) contaminated wounds. The rate of SSI was as high as 15 among 46(32.61%) dirty cases. The difference was statistical significant (p<0.01). It was revealed that the infection rate increased with that of degree of wound contamination (Table X). These findings were consistent with the findings of 10 years prospective study of 62,963 wounds by Cruse and Frood in 1980 [11], where infection rate was 1.5%, 7.7%, 15.2% and 40% in clean, clean contaminated, contaminated and dirty wounds respectively (Cruse and Frood 1980) [11]. Moreover, survey conducted by Ali and Khan in 1983 [12] at Chittagong Medical College Hospital observed SSI 25.00%, 28.60% and 54.80% respectively in clean, clean contaminated and contaminated wounds (Ali and Khan 1983) [12]. In addition, Renvall *et al.* in 1980 [6] in a prospective study carried out on 696 patients estimated SSI rates were 4.2%, 9.1% and 14.4% in clean, clean contaminated and dirty wounds respectively (Renvall *et al.*1980) [6]. In all the studies mentioned above rate of SSI raised with increase in the degree of wound contamination.

In relation to co-morbidity, it was observed that 42 patients had co-morbid disorders associated with the main surgical disease and 98 patients had no co-morbid disorder. Among the patients with co-morbid disorders, 17(40.48%) developed surgical site infection (SSI), whereas, in the patients without any co-morbidity only 7(7.14%) developed SSI (Table XI). The difference of rate of infection between these two groups was very obvious. It was clear that associated co-morbid disorders played a vital role as a host related risk factor for SSI. Moreover, the difference was statistically significant (p<0.001). It was observed that infection rate was 45.12 per cent in clinically malnourished patients, whereas it was 28.57 per cent in COPD cases and 33.33 per cent in obese patients. Moreover, two patients underwent laparotomy with medical jaundice. Of them one (50%) developed SSI. In addition, six patients with diabetes mellitus underwent emergency abdominal surgery. Of them two patients (33.33%) developed SSI (Table XII). Israelsson and Johnson [13] identified increased rate of SSI among overweight patients (Israelsson and Johnson 1997) [13]. Another study by Cruse and Frood [11] showed that clean wound infection rate rises to 10.7% in patients with diabetes, 13.5% in obesity and 16.6% in malnourished patients (Cruse and Frood 1980) [11]. Among 140 patients, 25 developed some type of discharge from the wounds/ collection of pus anywhere in the abdominal area. In 11cases there were mudy thin odourless pus, in 9 cases there were thick creamy pus, in 2 cases there were bluish green pus, in another 2 cases there were yellow fishy odoured pus and in 1 case there was serosanguinous discharge (Figure 18). Sample of pus or discharge from wound were sent for culture and sensitivity test in these 25 cases. One of them with serosanguinous discharge showed no growth, but the remaining 24 showed growth of various micro-organisms. *E. coli* were found in 11(45.83%) cases, the commonest organism causing surgical site infections (SSI). *Staph. Aureus* were the second most common organism found in 9(37.50%) cases. Each of *klebsiella* and *pseudomonas* were causing 2(8.33%) cases of SSI (Figure 19). These are supported by the findings of study conducted by Sultan *et al.* in 2007 [14]. They detected *Esch. Coli* as principal incriminated organism for SSI. Distribution of microflora involved was *E. coli* 47.7%, Proteus 14.8%, Pseudomonus 11.8%, Klebsiella 11.8%, Streptococcus 6.7%, Staphylococcus 5% and *Enterococi* 2.4% (Sultan *et al.* 2007) [14]. For the prevention of surgical site infection antibiotics such as Ceftriaxone, *Cefuroxim axetil*, Ciprofloxacin, Metronidazole were used in pre-operative and post-operative period in all of the cases. This has contrasting evidence as showed by Rasul and Ashraf [15] in their study conducted in 1979 who did not use antibiotics in any of 65 selected cases and there was not a single incidence of wound infection (Rasul and Ashraf 1979) [15]. Regarding sensitivity of the micro-organisms it was observed that, *Escherischia coli* were sensitive to Ciprofloxacin (45.45% cases), Cephradin (54.54% cases), Cotrimoxazole (45.45% cases), Nitrofurantoin (9.09% cases), Ceftriaxone (72.72% cases) and Imipenem (100% cases). All the cases of *E. coli* were resistant to Flucloxacillin (Table XIV). These findings are consistant with that of Iqbal *et al.* [16]. They studied sensitivity pattern on 378 isolates of *E. coli* from different sources and found susceptible to imepenem (99.7%), Tazobactum (99%), Amikacin (99%), Nitrofurantoin (92%), Ceftriaxone (66%) and ciprofloxacin (55%). Majority of the isolates were resistant to Cotrimoxazole (72%) and Ampicillin (76%), (Iqbal *et al.* 2002) [16]. *Staphylococcus aureus* were sensitive to Ciprofloxacin (44.45% cases), Cephradin (44.45% cases), Flucloxacin (55.55% cases), Ceftriaxone (88.90% cases) and Imipenem (100.00% cases). But, in all the cases *Staph. Aureus* were resistant to Cotrimoxazole and Nitrofurantoin. This finding can be compared with the findings of a national survey in Ireland done in 1993. The overall percentage of *S. aureous* sensitivity to the tested antibiotics were as follows: Methicillin 85%, penicillin 8%, gentamycin 89%, ciprofloxacin 85%, erythromycin 80%, fusidic acid 96% and mupirocin 98% (Moorhouse *et al.* 1996). Here, sensitivity of the organisms to ciprofloxacin is much higher than the present study. Results are inconstent with that of present study; it may be due to limited number of isolates in the present study and variation in the methodology.

Klebsiella pneumoniae were sensitive to Cephradin and Cotrimoxazole in 50 per cent cases each. All of the cases (100.00%) were sensitive to Ceftriaxone and Imipenem. But, all the cases of *Kl. Pneumoniae* were resistant to Ciprofloxacin, Flucloxacillin and Nitrofurantoin. These findings are similar to that of Sultan *et al.* [17] They stated in their study result that, the micro flora of intra-abdominal infections was usually found sensitive to 3rd generation cephalosporins, tazobactum, Imipenem, quinolones, clindamycin and amikacin (Sultan *et al.* 2007) [14]. Fifty per cent cases of *Pseudomonus aeruginosa* were sensitive to Ciprofloxacin and Nitrofurantoin. All the cases of *P. aeruginosa* (100.00%) sensitive to Ceftriaxone and Imipenem. All of them (100.00%) were resistant to Cephradin, Cotrimoxazole and Flucloxacillin. This finding is comparable with that of Ozumba, [17] Nigeria, who studied antibiotic sensitivity pattern on 229 clinical isolates of *Pseudomonus* *aeruginosa*. Majority of isolates tested were susceptible to Ceftazidim (88.5%), Colistin (83.75%), Ciprofloxacin 62.1%) and Ofloxacin (62.5%). These were less susceptible to Ceftriaxone (45.1%), Gentamycin (44.1%), Cotrimoxazole (0.7%) and Nitrofurantoin (6.7%), (Ozumba 2003) [17]. All the organisms isolated (100.00%) were sensitive to Imipenem because this is an excellent newer drug with broad spectrum of activity and another fact is that it is not a commonly used drug. so, development of resistance is uncommon. Use of newer drugs should be reserved for specific cases and must not be used empirically or prophylactically.

Limitations of the study

As this study has been carried out over a limited period of time with a limited number of patients and there was lack of financial and infrastructural support, it could not have been large enough to be of reasonable precision. All the facts and figures mentioned here may considerably vary from those of large series covering wide range of time, but still then, as the cases of this study were collected from a tertiary level hospital in our country, this study has some credentials in reflecting the facts regarding factors responsible for surgical site infection following emergency nontraumatic abdominal operations.

Conclusion

This descriptive type of cross-sectional study was conducted in surgery unit-1 of Mymensingh Medical College Hospital, Mymensingh, during the period from 1 August, 2009 to 31 July, 2010. It can be concluded from the findings of the study that micro-organisms that are normal inhabitants of our body are mainly responsible for surgical site infection (SSI). Various host factors like malnutrition, obesity, patients knowledge about hygiene, presence of co-morbidity etc. coupled with environmental factors such as condition of the wounds, delay to initiate operation, duration of operation, prolonged exposure of peritoneal cavity to environment, prophylactic use of antibiotics and factors associated with surgery like type of incision, type of operation and experience of operating surgeon greatly contribute to occurrences of SSI. So, quality of surgical care including immediate assessment of patients, resuscitative measures, adequate preparation of patients and aseptic environment are important for control of SSI. Moreover, in absence of highly advanced surgical amenities, preoperative resuscitative units, modern operation theatre facilities and sophisticated sterilization procedure it is necessary to use prophylactic antibiotics to encounter the various types of micro-organisms responsible for surgical site infection, particularly *E. coli* and *Staph. Aureus*.

Recommendations

On the basis of the findings of the study, the following recommendations can be made

- Prompt diagnosis, proper assessment, quick resuscitation and appropriate preoperative preparation are keys to better outcome in emergency operations, but undue delay should be avoided in treating any emergency condition.
- Duration of operation should be optimum to minimize the level of wound contamination and prevention of SSI.
- Emergency abdominal conditions should be managed by the experienced surgeons.
- Proper care of the patients as a whole throughout the peri-operative period is very vital to reduce the rate of surgical site infection.
- Appropriate antibiotic prophylaxis should be practiced.
- Further research is necessary in large scale for guidance regarding prevention of surgical site infections in our country.

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