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CLINICOBACTERIOLOGICAL STUDY OF SURGICAL SITE INFECTION

General Surgery

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ABSTRACT

Aims and Objectives: Surgical site infections are among the most common complications of inpatient admissions and have serious consequences for outcomes and costs. Different risk factors may be involved, including age, sex, nutrition and immunity, prophylactic antibiotics, operation type and duration, type of shaving, and secondary infections. This study aimed to determine the risk factors affecting surgical site infections and their incidence at Rajendra Institute of Medical Sciences, Ranchi.

Methods: A Prospective observational study was done in cases which were operated in Department of General Surgery, Rajendra Institute of Medical Sciences, Ranchi , regardless of age or associated co- morbidities like diabetes, jaundice, anaemia, and concomitant medication like steroids. Patients with stitch abscesses, wound site previously infected and trivial operation in outdoor cases were excluded.

Result: Incidence of surgical site infection in this study was 8.98%. Highest incidence of SSI (12%) was seen in the age group of 51-60 yrs. Elective surgeries had 7.17% incidence of SSI and emergency cases had a higher incidence of 14.89%. Anaemia was found to be the main risk factor for SSIs (23.3%). Overall imipenem, meropenem, piperacillin-tazobactum and amikacin were the most effective antibiotics.

Conclusion: A pre-existing medical illness, prolonged operating time, the wound class, emergency surgeries and wound contamination strongly predispose to surgical site infection. Antimicrobial prophylaxis is effective in reducing the incidence of post- operative wound infections for a number of different operative procedures but, timing of administration is critical.

KEYWORDS

Surgical Site Infection, Sepsis , Abscess , Clinocobacteriological SSI

INTRODUCTION :

Surgical site infection is a type of healthcare-associated infection in which a wound infection occurs after an invasive (surgical) procedure. Surgical site infections have been shown to compose up to 20% of all of healthcare-associated infections. At least 5% of patients undergoing a surgical procedure develop a surgical site infection.

A surgical site infection may range from a spontaneously limited wound discharge within 7–10 days of an operation to a life-threatening post-operative complication, such as a sternal infection after open heart surgery. Most surgical site infections are caused by contamination of an incision with microorganisms from the patient's own body during surgery. Infection caused by microorganisms from an outside source following surgery is less common.

Surgical site infections can have a significant effect on the quality of life for the patient. They are associated with considerable morbidity and extended hospital stay. In addition, surgical site infections result in a considerable financial burden to healthcare providers.

The majority of surgical site infections are preventable. Measures can be taken in the pre-, intra- and post-operative phases of surgical care to reduce the risk of infection. The incidence of surgical site infections can be reduced by appropriate patient preparation, timely peri-operative antibiotic administration, maintenance of peri-operative normothermia and normoglycemia, and appropriate wound management.

Although treatment of infection has been an integral part of the surgeon's practice since the dawn of time, the body of knowledge that led to the present field of surgical infectious disease was derived from the evolution of germ theory and antisepsis. Application of the latter to clinical practice, concurrent with the development of anaesthesia was pivotal in allowing surgeons to expand their repertoire to encompass complex procedures that previously were associated with extremely high rates of morbidity and mortality due to postoperative infections. However, until recently, the occurrence of infection related to the surgical wound was the rule rather than the exception. In fact, the development of modalities to effectively prevent and treat infection has occurred only within the last several decades[1].

Over the past 50 years, increased interest in the discipline of surgical infection has resulted in advances in post-surgical infection control. Early investigations focused on the importance of anaerobic microflora to post-operative infection and paved the way for significant improvements in prophylactic and therapeutic antibiotic treatment of surgical patients. Later research centered on the identification of risk factors to better predict post-operative infection rate.

Remarkable life saving discoveries has been made but infection causing organisms have also been successful in combating antibiotics and the search continues. The cost of an infected operation to the patient and the community cannot be simply measured in rupees and dollars. Surgeon should understand the real cost by analysing it in terms of morbidity and mortality. Everything that is done to reduce the infection rate costs money, so that it is important that the effectiveness of any new procedures introduced must be evaluated.

SSI can double the length of time a patient stays in hospital and thereby increase the costs of healthcare. The main additional costs are related to re-operation, extra nursing care and interventions, and drug treatment costs. The indirect costs, due to loss of productivity, patient dissatisfaction and litigation, and reduced quality of life, have been studied less extensively.(2)

Definitions

Surgical site infections (SSIs) are infections present in any location along the surgical tract after a surgical procedure[3].

Centers for Disease Control and Prevention Criteria for Defining a Surgical Site Infection[3].

1. Superficial Incisional

a. Infection less than 30 days after surgery
b. Involves skin and subcutaneous tissue only, *plus* one of the following:
- Purulent drainage
- Diagnosis of superficial surgical site infection by a surgeon
- Symptoms of erythema, pain, local edema

2 Deep Incisional

a. Less than 30 days after surgery with no implant and soft tissue involvement
b. Infection less than 1 year after surgery with an implant; involves deep soft tissues (fascia and muscle), *plus* one of the following:
- Purulent drainage from the deep space but no extension into the organ space
- Abscess found in the deep space on direct or radiologic examination or on reoperation

- Diagnosis of a deep space surgical site infection by the surgeon
- Symptoms of fever, pain, and tenderness leading to dehiscence of the wound or opening by a surgeon

3 Organ Space

a. Infection less than 30 days after surgery with no implant

b. Infection less than 1 year after surgery with an implant and infection; involves any part of the operation opened or manipulated, *plus* one of the following:

- Purulent drainage from a drain placed in the organ space
- Cultured organisms from material aspirated from the organ space
- Abscess found on direct or radiologic examination or during reoperation
- Diagnosis of organ space infection by a surgeon

1. Classification of Surgical Wounds[3].

CATEGORY	CRITERIA	INFECTION RATE
Clean	No hollow viscus entered Primary wound closure No inflammation No breaks in aseptic technique Elective procedure	1%-3%
Clean-contaminated	Hollow viscus entered but controlled No inflammation Primary wound closure Minor break in aseptic technique Mechanical drain used Bowel-preparation preoperatively	5%-8%
Contaminated	Uncontrolled spillage from viscus Inflammation apparent Open, traumatic wound Major break in aseptic technique	20%-25%
Dirty	Untreated, uncontrolled spillage from viscus Pus in operative wound Open suppurative wound Severe inflammation	30%-40%

2. Risk Factors for Postoperative Wound Infection[3].

PATIENT FACTORS	ENVIRONMENTAL FACTORS	TREATMENT FACTORS
• Ascites • Chronic inflammation • Undernutrition • Obesity • Diabetes • Extremes of age • Hypercholesterolemia • Hypoxemia • Peripheral vascular disease • Postoperative anemia • Previous site of irradiation • Recent operation • Remote infection • Skin carriage of staphylococci • Skin disease in the area of infection • Immunosuppression	• Contaminated medications • Inadequate disinfection/sterilization • Inadequate skin antisepsis • Inadequate ventilation • Presence of a foreign body	• Drains • Emergency procedure • Inadequate antibiotic coverage • Preoperative hospitalization • Prolonged operation

3. Pathogens Isolated From Postoperative Surgical Site Infections at a University Hospital[3].

PATHOGEN	PERCENTAGE OF ISOLATES
• *Staphylococcus* (coagulase negative)	25.6
• *Enterococcus* (group D)	11.5
• *Staphylococcus aureus*	8.7
• *Candida albicans*	6.5
• *Escherichia coli*	6.3
• *Pseudomonas aeruginosa*	6.0
• *Corynebacterium*	4.0
• *Candida* (non-*albicans*)	3.4
• - -Hemolytic*Streptococcus*	3.0
• *Klebsiella pneumoniae*	2.8
• Vancomycin-resistant *Enterococcus*	2.4
• *Enterobacter cloacae*	2.2
• *Citrobacter* species	2.0

- **MICROBIOLOGY OF INFECTIOUS AGENTS:-**

The pathogens associated with a surgical site infection reflect the area that provided the inoculum for the infection to develop. *Staphylococcus aureus* and coagulase-negative *Staphylococcus* remain the most common bacteria colonized from wounds.

In approximately one third of SSI cases, gram negative bacilli (Escherichia coli, Pseudomonas aeruginosa, and Enterobacter sp.) are isolated. However, at locations at which volumes of GI operations are performed, the predominant bacterial species are the gram negative bacilli. Infrequent pathogens are group-A beta haemolytic streptococci and clostridium perfringens. In recent years, the involvement of resistant organisms in the genesis of SSIs has increased, most notable in MRSA.[3]

MATERIALS AND METHODS :

Study Design: A Prospective observational study in the Department of General Surgery, Rajendra Institute of Medical Sciences, Ranchi was carried out from April 2018 to September 2019.

Study Area: Patients admitted in Department of General Surgery, Rajendra Institute of Medical Sciences, Ranchi in the above mentioned study period.

Sample size:.This was a prospective observational study. Total number of subjects in this study was 401 with power 88%. Subjects were randomly chosen from the patients who were undergone surgery at Department of Surgery, Rajendra Institute of Medical Sciences, Ranchi during the period April 2018 to September 2019 as per the study protocol.

STATISTICAL ANALYSIS

Statistical Analysis was performed with help of Epi Info (TM) 3.5.3. EPI INFO is a trademark of the Centers for Disease Control and Prevention (CDC). Descriptive statistical analysis was performed to calculate the means with corresponding standard deviations (S.D.).

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Test of proportion was used to find the Standard Normal Deviate (Z) to compare the difference proportions and Chi-square ($2X$) test was performed to find the associations. T-test was used to compare the means. Odds Ratio (OR) with 95% confidence interval (CI) had been calculated to find the risk factors. p≤0.05 was taken to be statistically significant.

INCLUSION CRITERIA

1. All cases which were operated in Department of General Surgery, Rajendra Institute of Medical Sciences, Ranchi in the above mentioned study period, regardless of age or associated co-morbidities like Diabetes, Jaundice, Anaemia, and concomitant medication like steroids.

EXCLUSION CRITERIA

1. Stitch Abscesses.
2. Wound site previously infected.
3. Trivial operation in outdoor cases would be excluded.

Method of collection of data:

An elaborate study of these cases with regard to date of admission, history, clinical features date of surgery, type of surgery, emergency or elective, preoperative preparation and postoperative management is done till patient is discharged from hospital, and then followed up the patient on OPD basis for any signs of wound infection. The wounds were examined for suggestive Signs/Symptoms of infection in the post operative period, during wound dressing or when the dressings were soaked.

In history, presenting complaints, duration, associated diseases, coexistent infections at a remote body site, personal history including diet, smoking, and alcoholism were noted. Operative findings which include type of incision, wound contamination, Drain used and its type and duration of operation were studied. Postoperative findings which included, day of wound infection, day of 1st Dressing and frequency of change of dressing.

Findings on the day of diagnosis of wound infection were noted which included fever, erythema, discharge, type and colour and the exudates was collected from the depth of the wound using sterile cotton swab and was sent to microbiology department for culture and sensitivity. Antibiotics used, their type, dosage, duration of used.

Procedure in laboratory:

In the Microbiology Department, the swabs were inoculated into blood agar plate, McConkey's agar plates and nutrient broth. Inoculated media were incubated aerobically at 37°C for 24-48 hrs. Nutrient broth was sub cultured if the original plates did not yield organisms. The bacteria isolated were identified by their morphological and cultural characteristics.

The samples collected were processed as follows:

a) Direct microscopic examination of gram stained smear
b) Inoculation of the samples into different culture media for aerobic and anaerobic organisms.
c) Preliminary identification.
d) Bio-chemical tests.
e) Antibiotic sensitivity.

Table-1incidence Of Surgical Site Infection

Total No. of cases	No. of cases infected	Percentage
401	36	8.98%

A study of 401 post-operative cases was carried out of which 36 were diagnosed to be having surgical site infection as per the CDC criteria. Thus the incidence of SSI in this study is 8.98%.

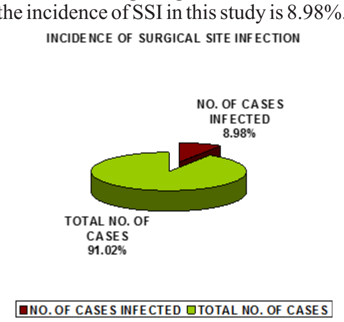

Table-2 Incidence In Relation To Sex

Gender	Total No. of cases	No. of cases infected	Percentage
Male	276	25	9.05 %
Female	125	11	8.8 %
Total	**401**	**36**	**8.98 %**

Test of proportion showed that there was no significant difference between the proportions of SSI among males (9.05%) and females (8.81%) (Z=0.09; p>0.05)

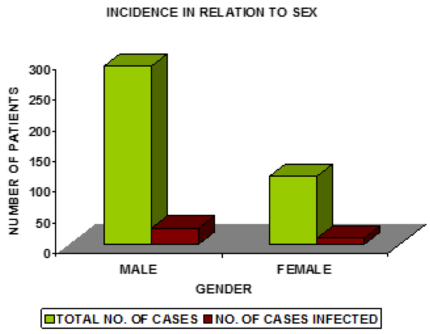

Table-3 Incidence In Relation To Age Group

Age group (years)	Total No. of cases	No. of cases infected	Percentage
12-20	20	1	5.00%
21-30	49	4	8.16%
31-40	69	6	8.70%
41-50	102	8	7.84%
51-60	125	15	12.00%
61-70	25	1	4.00%
71-80	11	1	9.09%
Total	**401**	**36**	**8.98%**

Proportion of SSI in the age group 51-60 years (12%) was significantly higher (2.08; p<0.05).

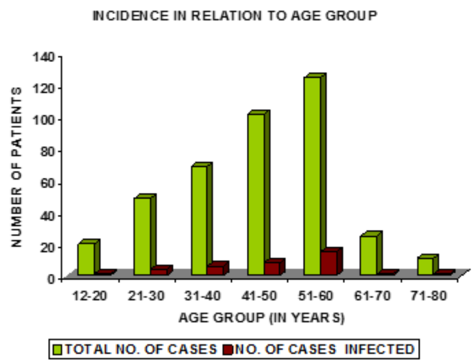

Table-4 Incidence In Relation To Type Of Surgery

Type of surgery	Total No. of cases	No. of cases infected	Percentage
Elective	307	22	7.17%
Emergency	94	14	14.89%
Total	**401**	**36**	**8.98%**

Proportion of SSI in emergency surgery (14.89%) was significantly higher (Z=2.29; p<0.05) than that of elective surgery.

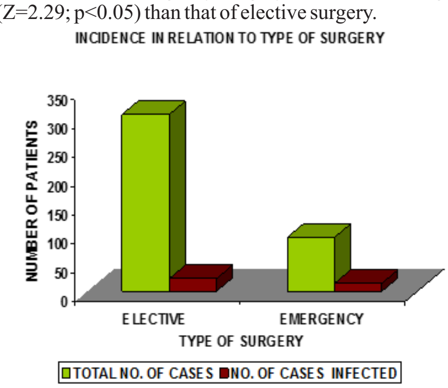

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Table-5 Incidence In Relation To Anemia, Dm, Hypoprotenimia, Immunodeficiency, Malignancy, Obesity And Smoking

Risk factors	Total No. of cases	No. of cases infected	Percentage
Anemia	60	14	23.33%
Diabetes mellitus	73	5	6.85%
Hypoproteinemia	38	6	15.79%
Immunodeficiency	14	2	14.29%
Malignancy	62	3	4.84%
Obesity	26	4	15.38%
Smoking	40	2	5.00%
TOTAL	**313**	**36**	**11.50%**

Incidence of SSI among the anaemic patients (23.33%) was significantly higher than other (Z=2.94; p<0.01).

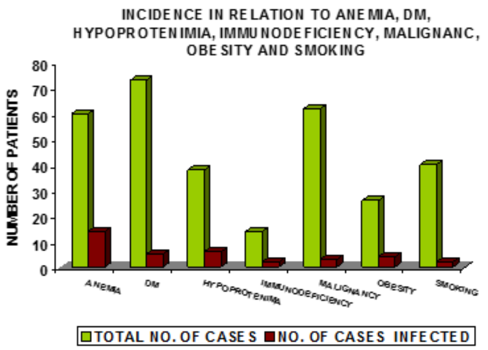


Table-6 :incidence In Relation To The Pre Operative Hospitali zation

No. of days	Total No. of cases	No. of cases infected	Percentage
1-5	303	22	7.26%
6-10	77	10	12.99%
11-15	21	4	19.05%
Total	**401**	**36**	**8.98%**

Incidence of SSI was significantly higher among the patients with pre-operative hospitalization of 11-15 days (Z=2.46; p<0.05).

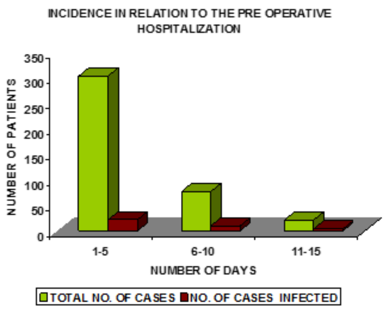


Table-7 Incidence In Relation To Diagnosis

Diagnosis	Total No. of cases	No. of cases infected	%
Acute appendicitis	56	4	7.14
Axillary mass	3	--	--
Basal Cell Carcinoma of Scalp	1	--	--
Benign prostatic hyperplasia	9	--	--
Carcinoma breast	42	2	4.76
Carcinoma rectum	16	5	31.25
Carcinoma penis	6	--	--
Carcinoma stomach	13	3	23.07
Cholelithiasis	29	7	24.13
Choledocholithiasia	12	2	16.67
Fibroadenoma breast	7	--	--
Hydatid cyst of liver	7	--	--
Incisional hernia	32	--	--
Inguinal hernia	54	4	7.4
Intestinal obstruction	11	1	9.09
Lipoma	10	--	--
Mesenteric cyst	4	--	--
Nephrolithiasis	8	--	--
Obstructed incisional hernia	5	--	--
Obstructed inguinal hernia	25	2	8.0
Parotid tumour	13	--	--
Peptic ulcer perforation	6	4	66.67
Periampullary carcinoma	2	--	--
Sigmoid volvulus	14	2	14.28
Thyroid goitre	10	--	--
Urinary bladder stone	6	--	--
Total	401	36	8.98%

Appendicectomy, cholecystectomy, laparotomy, hernioplasty, and modified radical mastectomy were the most common operations performed. Surgical site infection was more common among peptic ulcer perforation (66.67%), carcinoma rectum (31.25%), cholelithiasis (24.13%) and carcinoma stomach (23.07%).

Table–8 Incidence In Relation To Prophylactic Antibiotic

Pre operative antibiotics	Total No. of cases	No. of cases infected	Percentage
Given	302	21	6.95%
Not given	99	15	15.15%
Total	**401**	**36**	**8.98%**

Incidence of SSI was significantly higher for patients who were not given pre-operative antibiotics (15.15%) (Z=2.47;p<0.05).

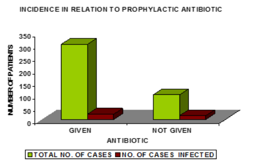
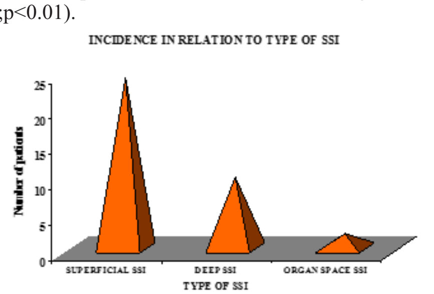


Table-9 Incidence In Relation To Type Of Ssi

Type of SSI	No. of cases infected	Percentage
Superficial SSI	24	66.67%
Deep SSI	10	27.78%
Organ space SSI	2	5.55%
Total	**36**	**100%**

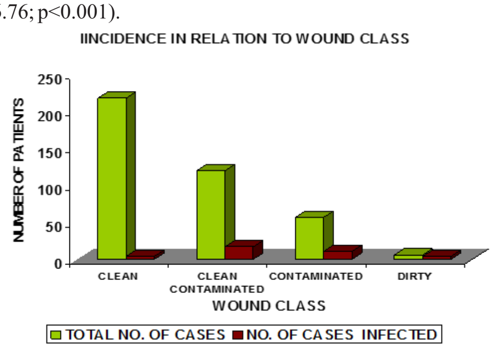
Proportion of superficial SSI (66.67%) was significantly higher (Z=5.51;p<0.01).



Table–10 Incidence In Relation To Wound Class

Type	Total No. of cases	No. of cases infected	Percentage
Clean	218	4	1.83%
Clean contaminated	120	17	14.16%
Contaminated	57	11	19.29%
Dirty	6	4	66.66%
Total	**401**	**36**	**8.98%**

Proportion of SSI in dirty wounds (66.67%) was significantly higher (Z=6.76; p<0.001).



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Table–11 Incidence In Relation To Duration Of Surgery

Duration (in hours)	Total No. of cases	No. of cases infected	Percentage
<1 Hour	199	9	4.52%
1 to 2 hours	151	17	11.26%
>2 Hours	51	10	19.61%
Total	**401**	**36**	**8.98%**

Proportion of SSI for duration of surgery > 2 hours (19.61%) was significantly higher (Z=3.21; p<0.01).

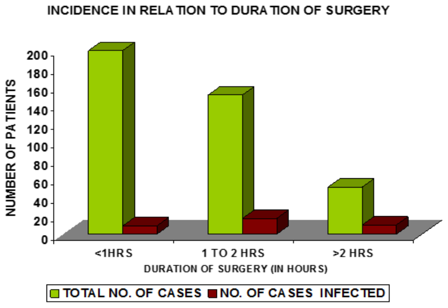


Table 12 Incidence In Use Of Drain And Mesh

Use of drain & mesh	Total No. of cases	No. of cases infected	Percentage
Drain	121	14	11.57%
Mesh	77	6	7.79%
Mesh+Drain	25	2	8.00%

There was no significant difference in the proportions of SSI in drain (11.57%), mesh (7.79%) and mesh and drain (8.00%) (Z=0.84; p>0.05).

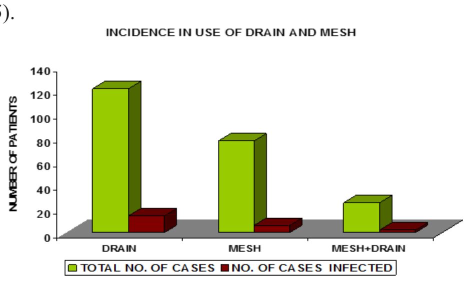
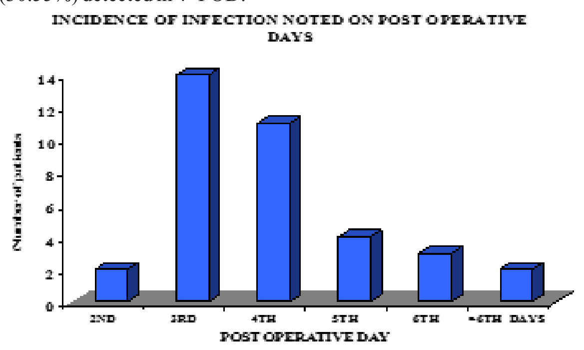


Table-13 Incidence Of Infection Noted On Post Operative Days

Days	No. of cases infected	Percentage
2nd	2	5.55%
3rd	14	38.88%
4th	11	30.55%
5th	4	11.11%
6th	3	8.33%
>6th days	2	5.55%
Total	**36**	**100%**

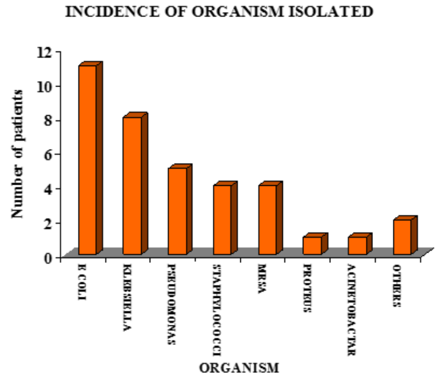
14 cases (38.88%) had infection detected in 3rd POD and 11 cases (30.55%) detected in 4th POD.



Table–14 Incidence Of Organism Isolated

Organism	No. of cases infected	Percentage
E. coli	11	30.56%
Klebsiella	8	22.22%
Pseudomonas	5	13.89%
Staphylococci	4	11.11%
MRSA	4	11.11%
Proteus	1	2.78%
Acinetobacter	1	2.78%
Others	2	5.56%
Total	**36**	**100.00%**

Proportions of E. coli (30.56%) and Klebsiella (22.22%) infections were significantly higher (Z=3.38; p<0.01).



Table–15 Organisms Isolated In Wound Types

Micro-organism	Clean	Clean Contaminated	Contaminated	Dirty	Total
Acinetobacter	0	0	1	0	1
Row %	0.0	0.0	100.0	0.0	100.0
Col %	0.0	0.0	9.1	0.0	2.8
E. coli	0	6	4	1	11
Row %	0.0	54.5	36.4	9.1	100.0
Col %	0.0	35.3	36.4	25.0	30.6
Klebsiella	0	6	2	0	8
Row %	0.0	75.0	25.0	0.0	100.0
Col %	0.0	35.3	18.2	0.0	22.2
MRSA	0	2	1	1	4
Row %	0.0	50.0	25.0	25.0	100.0
Col %	0.0	11.8	9.1	25.0	11.1
Proteus	0	0	1	0	1
Row %	0.0	0.0	100.0	0.0	100.0
Col %	0.0	0.0	9.1	0.0	2.8
Pseudomonas	0	3	2	0	5
Row %	0.0	60.0	40.0	0.0	100.0
Col %	0.0	17.6	18.2	0.0	13.9
Staphylococci	4	0	0	0	4
Row %	100.0	0.0	0.0	0.0	100.0
Col %	100.0	0.0	0.0	0.0	11.1
Others	0	0	0	2	2
Row %	0.0	0.0	0.0	100.0	100.0
Col %	0.0	0.0	0.0	50.0	5.6
Total	4	17	11	4	36
Row %	11.1	47.2	30.6	11.1	100.0
Col %	100.0	100.0	100.0	100.0	100.0

X^2=59.83; p=0.00001 S- Significant

Chi-square (X^2) test showed that there was significant association between type of microorganism and type of wounds (p=0.00001).

E. coli, Klebsiella, Pseudomonas were most commonly isolated from clean contaminated wound (54.5%, 75% and 60% cases respectively).

Staphylococci are most commonly isolated with clean wounds.

Table–16 Comparison Of Organisms Isolated With Pre Operative Hospitalisation

Micro-organism	Pre-operative Hospitalisation (in days)			Total
	Up to 5 Days	5-10 Days	>10 Days	
Acinetobacter	1	0	0	1
Row %	100.0	0.0	0.0	100.0
Col %	4.5	0.0	0.0	2.8
E. coli	6	4	1	11
Row %	54.5	36.4	9.1	100.0
Col %	27.3	40.0	25.0	30.6

Klebsiella Row % Col %	6 75.0 27.3	1 12.5 10.0	1 12.5 25.0	8 100.0 22.2
MRSA Row % Col %	3 75.0 13.6	1 25.0 10.0	0 0.0 0.0	4 100.0 11.1
Others Row % Col %	2 100.0 9.1	0 0.0 0.0	0 0.0 0.0	2 100.0 5.6
Proteus Row % Col %	0 0.0 0.0	1 100.0 10.0	0 0.0 0.0	1 100.0 2.8
Pseudomonas Row % Col %	2 40.0 9.1	2 40.0 20.0	1 20.0 25.0	5 100.0 13.9
Staphylococcus Row % Col %	2 50.0 9.1	1 25.0 10.0	1 25.0 25.0	4 100.0 11.1
Total Row % Col %	22 61.1 100.0	10 27.8 100.0	4 11.1 100.0	36 100.0 100.0

x^2=8.21; p=0.87 NS- Not Significant

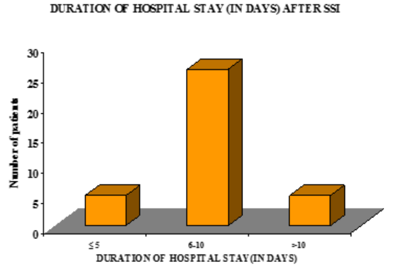
Chi-square (x^2) test showed that there was no significant association between type of microorganism and pre-operative hospitalization (p=0.87).

E. coli caused 54.5% of infection upto 5 days of pre operative hospitalisation and MRSA and Klebsiella caused 75% infection in the same period. Proteus caused 100% of infection in 6–10 days pre operative period.

Table–17 Duration Of Hospital Stay (in Days) After Ssi

Duration of hospital stay (days)	Number	Percentage
≤ 5	5	13.9%
6-10	26	72.2%
>10	5	13.9%
Total	36	100.0%

The mean duration of hospital stay (mean±S.D.) of the patients was 7.83±2.26 days with range 5-14 days and the median was 7 days. Most of the patients (72.2%) stayed in hospital for 6-10 days (Z=4.99; p<0.001).



Table–18 Type Of Antibiotics Used In Ssi

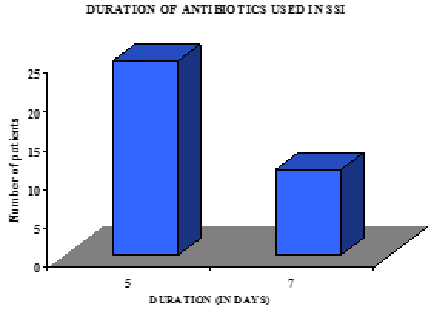
Antibiotic used	Number	Percentage
AK	2	5.6%
AK LF	1	2.8%
AK PZ	1	2.8%
AK,PZ	1	2.8%
AM	2	5.6%
AM PZ	1	2.8%
AMC	3	8.3%
AMC,CD	1	2.8%
CF	1	2.8%
CM LF	1	2.8%
CSB	1	2.8%
IM	10	27.8%
IM AK	1	2.8%
LF	2	5.6%
MER	1	2.8%
PZ	5	13.9%
V	2	5.6%
Total	36	100.0%

Most of the patients were treated with imipenem, amikacin, piperacillin+tazobactum, amoxicilin+clavulinic acid.

Table–19 Duration Of Antibiotics Used In Ssi

Duration of antibiotics (in days)	Number	Percentage
5	25	69.4%
7	11	30.6%
Total	36	100.0%

The mean duration of antibiotics used (mean±S.D.) was 5.61±0.93 days with range 5-7 days and the median was 5 days.



TABLE–20 (a) :ANTIBIOTIC SENSITIVITY SPECTRUM

Micro-organisms	CZ	%	CM	%	CD	%	AMC	%	AZ	%
E. coli (n=11)	5	45.4	5	45.4	7	63.6	6	54.5	3	27.2
Klebsiella (n=8)	3	37.5	2	25.0	4	50.0	2	25.0	3	37.5
Pseudomonas (n=5)	2	40.0	2	40.0	2	40.0	1	20.0	1	20.0
Staphylococci (n=4)	3	75.0	3	75.0	3	75.0	4	100.0	3	75.0
MRSA (n=4)	0	0.0	1	25.0	1	25.0	0	0.0	0	0.0
Proteus (n=1)	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Acinetobacter (n=1)	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Others (n=2)	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0

CZ- CEFTRIAXONE; CM- CEFOTAXIM; CD- CEFTAZIDIME; AMC-AMOXICILLIN+CLAVULINIC ACID; AZ-AZITHROMYCIN

TABLE–20 (b) ANTIBIOTIC SENSITIVITY SPECTRUM (Continued)

Micro-organisms	AK	%	G	%	CSB	%	PZ	%	V	%
E. coli (n=11)	8	72.7	8	72.7	8	72.7	8	72.7	3	27.27
Klebsiella (n=8)	6	75.0	2	25.0	4	50.0	7	87.5	4	50.0
Pseudomonas (n=5)	3	60.0	1	20.0	3	60.0	4	80.0	3	60.0
Staphylococci (n=4)	2	50.0	1	25.0	1	25.0	3	75.0	2	50.0
MRSA (n=4)	2	50.0	1	25.0	3	75.0	3	75.0	2	50.0
Proteus (n=1)	1	100.0	1	100.0	1	100.0	0	0.0	1	100.0
Acinetobacter (n=1)	1	100.0	1	100.0	1	100.0	1	100.0	1	100.0
Others (n=2)	1	50.0	0	0.0	2	100.0	2	100.0	0	0.0

AK- AMIKACIN; G- GENTAMYCIN; CSB- CEFOPERAZONE+ SULBACTUM; PZ-PIPERACILLIN+TAZOBACTUM; V- VANCOMYCIN

Table–20 (c)antibiotic Sensitivity Spectrum (continued)

Micro-organisms	CL	%	CF	%	LF	%	IM	%	MER	%

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E. coli (n=11)	3	27.2	6	54.5	8	72.7	10	90.9	10	90.9
Klebsiella (n=8)	6	75.0	4	50.0	6	75.0	7	87.5	7	87.5
Pseudomonas (n=5)	3	60.0	1	20.0	1	20.0	4	80.0	4	80.0
Staphylococci (n=4)	2	50.0	1	25.0	3	75.0	4	100.0	4	100.0
MRSA (n=4)	2	50.0	1	25.0	1	25.0	4	100.0	4	100.0
Proteus (n=1)	1	100.0	1	100.0	1	100.0	1	100.0	1	100.0
Acinetobacter (n=1)	1	100.0	0	0.0	0	0.0	1	100.0	1	100.0
Others (n=2)	1	50.0	0	0.0	0	0.0	2	100.0	2	100.0

CL-CLINDAMYCIN; CF-CIPROFLOXACINE; LF-LEVOFLOXACINE; IM-IMIPENEM, MER-MEROPENEM

E. coli is most sensitive for Imipenem, meropenem (90.9%) followed by amikacin, piperacillin-tazobactum, cefoperazone+ sulbactum, levofloxacine, gentamycin (72.7%). Klebsiella is most sensitive for Imipenem, meropenem (87.5%) followed by amikacin, piperacillin-tazobactum, levofloxacine, clindamycin (75%). Pseudomonas is most sensitive for Imipenem, meropenem, piperacillin-tazobactum (80%), followed by clindamycin, amikacin, cefoperazone+sulbactum and vancomycin (60%). Staphylococci is most sensitive for amoxicillin +clavulinic acid, Imipenem, meropenem (100%), followed by piperacillin-tazobactum, ceftriaxone, cefotaxim, ceftazidime, azithromycin (75%). MRSA is most sensitive to Imepenem, meropenem (100%) then piperacillin-tazobactum, cefoperazone +sulbactum (75%). Proteus, acinobactar and others were most sensitive to higher antibiotics like Imepenem, meropenem, followed by piperacillin-tazobactum. Overall imipenem, meropenem, piperacillin-tazobactum are the most effective antibiotics.

Table-21 (a) : Antibiotic Resistance Spectrum

Micro-organism	CZ	%	CM	%	CD	%	AMC	%	AZ	%
E. coli (n=11)	6	54.5	6	54.5	5	45.5	8	72.7	3	27.2
Klebsiella (n=8)	5	62.5	6	75.0	4	50.0	6	75.0	5	62.5
Pseudomonas (n=5)	3	60.0	3	60.0	3	60.0	4	80.0	4	80.0
Staphylococci (n=4)	1	25.0	1	25.0	1	25.0	0	0.0	1	25.0
MRSA (n=4)	4	100.0	3	75.0	3	75.0	4	100.0	4	100.0
Proteus (n=1)	1	100.0	1	100.0	1	100.0	1	100.0	1	100.0
Acinetobacter (n=1)	1	100.0	1	100.0	1	100.0	0	0.0	0	0.0
Others (n=2)	2	100.0	2	100.0	2	100.0	2	100.0	2	100.0

CZ- CEFTRIAXONE
CM- CEFOTAXIM
CD- CEFTAZIDIME
AMC-AMOXICILLIN+CLAVULINIC ACID
AZ- AZITHROMYCIN

Table- 21(b) : Antibiotic Resistance Spectrum (continued)

Micro-organism	AM	%	G	%	CSB	%	PZ	%	V	%
E. coli (n=11)	3	27.2	4	36.4	3	27.2	3	27.2	8	72.7
Klebsiella (n=8)	2	25.0	6	75.0	4	50.0	1	25.0	4	50.0
Pseudomonas (n=5)	2	40.0	4	80.0	2	40.0	1	20.0	2	40.0
Staphylococci (n=4)	2	50.0	3	75.0	3	75.0	1	25.0	2	50.0
MRSA (n=4)	2	50.0	3	75.0	1	25.0	1	25.0	2	50.0
Proteus (n=1)	1	100.0	0	0.0	0	0.0	0	0.0	1	100.0
Acinetobacter (n=1)	0	0.0	0		0	0.0	0	0.0	0	0.0
Others (n=2)	1	50.0	2	100.0	0	0.0	0	0.0	2	100.0

AK- AMIKACIN, G- GENTAMYCIN , CSB- CEFOPERAZONE +SULBACTUM PZ-PIPERACILLIN +TAZOBACTUM , V-VANCOMYCIN

Table-21(c): Antibiotic Resistance Spectrum (continued)

Micro-organism	CL	%	CF	%	LF	%	IM	%	MER	%
E. coli (n=11)	8	72.7	5	45.5	3	27.2	1	9.1	1	9.1
Klebsiella (n=8)	2	25.0	4	50.0	2	25.0	1	12.5	1	12.5
Pseudomonas (n=5)	2	40.0	4	80.0	4	80.0	1	20.0	1	20.0
Staphylococci (n=4)	2	50.0	3	75.0	1	25.0	0	0.0	0	0.0
MRSA (n=4)	2	50.0	3	75.0	3	75.0	0	0.0	0	0.0
Proteus (n=1)	0	0.0	0		0	0.0	0	0.0	0	0.0
Acinetobacter (n=1)	0	0.0	1	100.0	1	100.0	0	0.0	0	0.0
Others (n=2)	1	50.0	2	100.0	2	100.0	0	0.0	0	0.0

CL- CLINDAMYCIN
CF- CIPROFLOXACINE
LF- LEVOFLOXACINE
IM- IMIPENEM
MER- MEROPENEM

Ecoli is most resistant to clindamycin, vancomycin and amoxicillin +clavulinic acid (72.7%). Klebsiella is most resistant to cefotaxime, amoxicillin+ clavulinic and gentamycin (75%). Pseudomonas is most resistant to amoxicillin+clavulinic, azithromycin, gentamycin, ciprofloxacine and levofloxacine (80%). Staphylococci is most resistant to gentamycin, ciprofloxacin and, cefoperazone+sulbactum (75%).

MRSA is most resistant to ceftrixone, amoxicillin+clavulinic, azithromycin (100%) then levofloxacin, ciprofloxacine, gentamycin, cefotaxime and ceftadizime (75%).

Proteus, acinetobacter and others were most resistant to antibiotics like- ceftriaxone, cefotaxim, ceftazidime, amoxicillin+ clavulinic acid, azithromycin amikacin, gentamycin, ciprofloxacine, levofloxacine (100%). Overall there was more resistance to ceftriaxone, cefotaxim, ceftazidime, gentamycin.

DISCUSSION:

The present study was conducted at Department of Surgery, Rajendra Institute of Medical Sciences, Ranchi.

This was a prospective observational study of 401 cases who underwent surgery and were followed up from the day of operation to 30 days after discharge to look for the development of SSI.

INCIDENCES OF SSI

A study of 401 post-operative cases was carried out of which 36 were diagnosed to be having surgical site infection. The incidence of SSI was 8.98%.

The incidence rate in this study is well within the infection rates of 0.1% to 50.4%[18] seen in other studies. Different studies from India at different places have shown the SSI rate to vary from 6.09% to 38.7%. The infection rate in Indian hospitals is much higher than that in other countries; for instance in the USA, it is 2.8% and it is 2-5% in European countries. The higher infection rate in Indian hospitals may be due to the poor set-up of our hospitals and also due to the lack of attention towards the basic infection control measures.

The following table shows incidence in various other studies.

Author	Country	Year	Cases	Incidence
Hayama et al[15]	Japan	2014	203	10.8%
Bekiari et al[32]	Greece	2013	207	7.7%
Khan Mansoor et al[35]	Pakistan	2011	304	9.29%
Barnali et al[4]	India	2013	685	7.44%
Satyanarayana V et al[6]	India	2011	1000	13.7%
Our study	India	2019	401	8.98%

INCIDENCE IN RELATION TO SEX

Incidence of SSI among males was 9.05% and among females was 8.8%.

Mahesh C B et al[7] showed 21% and 18.88% incidence of SSI among males and females respectively.

Thus, our result showed no significant difference between gender and incidence of SSI.

AGE

The present study shows that the incidence of SSI is more among 51-60 yrs. age group followed by 31-40 years group, probably due to more number of surgeries performed in these age groups. The younger age groups had lesser incidence of SSI. This confirms the understanding that there is a gradual rise in incidence of wound infection as age advances, although in this study the 61-70 age group had lesser incidence owing to lesser number of surgeries in this group.

Son JI et al[14] found higher incidence of SSI in the age group of 51-60 yrs.

Mizrahi I et al[17] reported higher incidence of SSI above the age of 60 yrs. Age, obviously is an immutable patient characteristic and even, if it is a risk factor for wound infection, it appears to be at most a modest one.

EMERGENCY/ ELECTIVE

The SSI rate in elective surgeries in our study was found to be 7.17%, which was found to increase to 14.89% in emergency surgeries.

INCIDENCE OF SSI IN ELECTIVE AND EMERGENCY		
Study	Elective	Emergency
Barnali et al[4]	4.86%	15.2%
Satyanarayana V et al[6]	7.6%	25.2%
Our study	7.17%	14.89%

The high rates of infection in emergency surgeries can be attributed to inadequate pre operative preparation, the underlying conditions which predisposed to the emergency surgery and the more frequency of contaminated wounds in emergency surgeries.[6]

RISK FACTORS LIKE ANEMIA, DM, HYPOPROTENIMIA, IMMUNODEFICIENCY, MALIGNANCY, OBESITY AND SMOKING

Incidence of SSI among the patients with risk factors was- Anaemia (23.33%), Hypoproteinemia (15.79%), obesity (15.38%), immunodeficiency (14.29%), Diabetes Mellitus (6.85%), smoking (5.00%), malignancy (4.84%).

Fischer JP et al[25] reported that medical comorbidities including obesity (63.4%), smoking (24.9%), hypertension (53.1%), diabetes (19.9%), and anemia (22.6%) increased the rate of surgical site infection.

Similar results were also obtained in other studies.[31]
Variable results were also obtained in other studies.[13][15][22][23][24][25][26][27][28][29][30][34][35]

RELATION TO THE PRE OPERATIVE HOSPITALIZATION

Incidence of SSI was significantly higher among the patients with pre-operative hospitalization of 11-15 days (Z=2.46; p<0.05)

Mahesh CB[7] et al found that as the duration of the pre-operative stay increased, the rate of SSIs also increased. The difference in the rate of infection was analyzed statistically and was found to be significant (p=0.00109).

Lilani SP[5] reported that the incidence of SSI increased with increase in the duration of pre-operative stay and the difference was found to be statistically significant (0.0035%).

The rates of SSIs increased with the increasing duration of pre operative hospitalization. The higher incidence of infections due to a longer stay in the hospital could be attributed to the increased colonization of patients with nosocomial strains in the hospital with staphylococcus aureus and MRSA and also, a longer pre-operative stay in the hospital reflected the severity of the illness and the co- morbid conditions which required patient work- up and or therapy before the operation. Similar results were obtained in other studies.

ANTIBIOTIC PROPHYLAXIS

Incidence of SSI in patients who did not receive pre operative antibiotic prophylaxis was 15.15 % compared to 6.95 % incidence in patients who received pre operative antibiotic prophylaxis.

Mahesh CB[7] et al reported that SSIs were seen in 14 (20%) patients who had not received pre operative antibiotic therapy and in 16(8.42%) cases in patients who had received pre operative antibiotic therapy. The difference in the rate of infection was found to be significant (p=0.0095)

Antibiotic prophylaxis reduced the microbial burden of the intra operative contamination to a level that could not overwhelm the host defences. The pre operative antibiotic prophylaxis could decrease post operative morbidity, shorten the hospital stay and it could also reduce the overall costs which were attributable to the infection.[7][16][21][23][26][28][34][37]

INCIDENCE IN RELATION TO TYPE OF SSI

Most of the SSIs were superficial type constituting 66.67% of infected cases followed by deep SSIs (27.78%) and organ space infections (5.55%).

INCIDENCE IN RELATION TO TYPE OF SSI			
Study	Superficial SSI	Deep SSI	Organ space SSI
Neuman D et al[24]	72.7 %	27.3 %	-
Akokol L.O[33]	54.8%.	-	-
Our study	66.67%	27.78%	5.55%

TYPES OF WOUND

In this study, regarding incidence in relation to the type of surgery, clean cases had infection rate of 1.83%, clean contaminated cases had incidence of 14.16%, contaminated cases had incidence of 19.29% and dirty cases had incidence of 66.66%, which was similar to the findings in other studies.

INCIDENCE IN RELATION TO WOUND CLASS				
Study	Clean	Clean contaminated	Contaminated	Dirty
Mahesh CB[7]	11.53%	23.33%	38.09%	57.14%
Kamat US[9]	5.4%	35.5%	77.8%	-
Maksimovic J et al[12]	13.2 %	-	-	70.0%
Our study	1.83%	14.16%	19.29%	66.66%

INCIDENCE IN RELATION TO DURATION OF SURGERY

- 49.62% cases with duration of surgery of less than 1 hour showed an incidence of SSI of 4.52%.
- 37.65% of cases with duration of surgery of 1 to 2 hours showed an incidence of SSI of 11.26%
- 12.71% cases with duration of surgery of >2 hrs showed an incidence of SSI of 19.61%.
- These results were comparable to the findings of other studies on SSIs.

INCIDENCE IN RELATION TO DURATION OF SURGERY			
Study	<1 hours	1-2 hours	>2 hours
Barnali et al[4]	6.66%	6.23%	38.46%
Lilani SP[5]	1.47%	-	38.46%
Our study	4.52%	11.26%	19.61%

INCIDENCE IN USE OF DRAIN AND MESH

Incidence of SSI in cases with usage of drain, mesh and drain+mesh was 11.57 %, 7.79 % and 8.0 % respectively.

Barnali et al[4] reported SSI incidence of 15.75% in cases of drain usage compared to 1.95% incidence of SSI in cases without usage of drain.

Lilani SP[5] drain had infection 22.41% than non drain 3.03%. El-Gazzaz GH[42] reported SSI incidence of 22.5% in cases of mesh usage.

The infection rate increases with the increasing duration of the drain. Similar observations were made in other studies on SSI, and could be attributed to the nature of operation necessitating the drainage, the drain acting as the portal of entry, or the effect of the drain itself.

INCIDENCE OF ORGANISM ISOLATED

Most common organism isolated in our study is E-coli was 30.56%, followed by Klebsiella (22.22%), Pseudomonas (13.89%), followed by Staph. aureus and MRSA was 11.11%.

Study	Incidence of E. coli in SSI
Barnali et al[4]	41.17%.
Kamat US[9]	79%.
Bekiari A	61.5%.
Seni J[10]	23.7%
Our Study	30.56 %

Our findings of a predominance of gram negative bacilli are similar to that of other studies. In most cases of SSI the organism is usually the patient's endogenous flora. In abdominal surgeries the opening of the gastrointestinal tract increases the likelihood of coliforms, gram negative bacilli infection which was our finding in this study. This group of organisms tends to be endemic in hospital environment by being easily transferred from object to object, they also tend to be resistant to common antiseptics and are difficult to eradicate in the long term. This group of organisms is increasingly playing a greater role in the many hospital acquired infections.

ORGANISMS ISOLATED IN WOUND TYPES

Chi-square (X^2) test showed that there was significant association between type of microorganism and type of wounds (p=0.00001).

E. coli, Klebsiella, Pseudomonas were most commonly isolated from clean contaminated wounds in 54.5%, 75% and 60% cases respectively.

Staph.aureus was most commonly isolated from clean wounds- 100% cases.

Healy B et al[43] reported that in "clean" surgery, (i.e. non-emergency surgery that does not enter the gastrointestinal or genitourinary tract), when infection does occur, antibiotic-resistant organisms, such as methicillin resistant *Staphylococcus aureus* (MRSA) and in contaminated surgery, enterobacteriaceae was most common.

Seni J[10] found that in clean contaminated and contaminated surgery, enterobacteriaceae group of organisms were more commonly isolated.

ORGANISMS ISOLATED WITH PRE OPERATIVE HOSPITALISATION

Chi-square () test showed that there was no significant association between type of microorganism and pre-operative hospitalization (p=0.87).

E. coli caused 54.5% of infection upto 5 days pre op hospitalisation and MRSA and Klebsiella caused 75% infection in the same period. Proteus caused 100% of infection in 6 – 10 days pre op period. During >10 days period staphylococcus caused only 25% of the infections.

Engemann JJ et al[19] found that MRSA infection was more common in cases of prolonged pre-operative hospitalization.

DURATION OF HOSPITAL STAY (IN DAYS) AFTER SSI

The mean duration of hospital stay (mean±S.D.) of the patients was 7.83±2.26 days with range 5-14 days and the median was 7 days. Most of the patients (72.2%) stayed in hospital for 6-10 days (Z=4.99;p<0.001).

Kirkland KB[11] reported that patients who develop SSI have longer duration of hospitalisations.

Gregory DL et al[20] reposted that SSI extended length of hospital stay by an average of 9.7 days.

TYPE OF ANTIBIOTICS USED IN SSI

Most of the patients were treated with imipenem, amikacin, piperacillin+tazobactum, amoxicillin+clavulanic acid, cefoperazone-sulbactum, which was also the case in most of the other studies.

ANTIBIOTIC SENSITIVITY AND RESISTANCE

E. coli was found to be most sensitive to Imipenem, meropenem (90.9%) followed by amikacin, piperacillin-tazobactum, cefoperazone + sulbactum, levofloxacine, gentamycin (72.7%).

Klebsiella was found to be most sensitive to Imipenem, meropenem (87.5%) followed by amikacin, piperacillin-tazobactum, levofloxacin, clindamycin (75%).

Pseudomonas was found to be most sensitive toImipenem, meropenem, piperacillin-tazobactum (80%) followed by clindamycin, amikacin, cefoperazone+sulbactum and vancomycin (60%).

Staphylococci was most sensitive to amoxicillin+clavulinic acid, Imepenem, meropenem (100%), followed by piperacillin-tazobactum, ceftriaxone, cefotaxim, ceftazidime, azithromycin (75%).

MRSA was found to be most sensitive to Imipenem, meropenem (100%), followed by piperacillin-tazobactum, cefoperazone + sulbactum (75%).

Proteus, Acinetobacter and others were most sensitive to higher antibiotics like Imipenem, meropenem followed by piperacillin-tazobactum.

E. coli was found to be most resistant to clindamycin, vancomycin and amoxicillin+clavulinic acid (72.7%).

Klebsiella was found to be most resistant to cefotaxime, amoxicillin+clavulinic and gentamycin (75%).

Pseudomonas was most resistant to amoxicillin+clavulinic, azithromycin, gentamycin, ciprofloxacine and levofloxacine (80%).

Staphylococci was most resistant to gentamycin, ciprofloxacine and, cefoperazone+sulbactum (75%).

MRSA was most resistant to ceftriaxone, amoxicillin+ clavulinic, azyithromycin (100%), followed by levofloxacin, ciprofloxacin, gentamycin, cefotaxime and ceftadizime (75%).

Proteus, Acinetobacter and others were most resistant to antibiotics like- ceftriaxone, cefotaxim, ceftazidime, amoxicillin+ clavulinic acid, azithromycin amikacin, gentamycin, ciprofloxacine, levofloxacine(100%).[4][7][8][9][10][19][36][38][39][40][41]

Seni J[10] reported that Amikacin and Imipenem for ESBL-producing Enterobacteriacea and Vancomycin for MRSA showed excellent performance[10].

Naik NR[8] found that most of the Gram negative organisms were sensitive to piperacillin/tazobactam, ceftazidime and amikacin and all of them were sensitive to imipenem. Gram positive organisms were found to be more sensitive to gentamicin, clindamycin and linezolid. Sensitivity to vancomycin was seen in all the Gram positive isolates. 22.2% strains of Staph. Aureus were methicillin-resistant by cefoxitin disc diffusion test and by oxacillin E-test. ESBL production was seen among 25% and 22.22% isolates of Klebsiella pneumonia and Escherichia coli respectively.

Overall, more cases of resistance were seen to ceftriaxone, cefotaxim, ceftazidime and gentamycin.

The relative frequency of different isolates also varied between different studies. Thus, it can be concluded that the organisms that cause SSIs change from place to place and from time to time in the same place. The review of literature indicates that there is gradual increase in drug resistance to many antibiotics in most of the organisms which are isolated from surgical patients. Our study reveals that though SSIs have been widely studied since a long time, they still remain as one of the most important causes of morbidity and mortality in surgically treated patients. The steps taken to reduce SSIs are still not adequate. Proper infection control measures and a sound antibiotic policy should reduce SSIs in the future.

SUMMARY

- Incidence of surgical site infection in this study was 8.98%.
- Highest incidence of SSI (12%) was seen in the age group of 51-60 yrs.
- Proportion of superficial SSI (66.67%) was significantly higher than that of deep and organ space SSIs.
- Elective surgeries had 7.17% incidence of SSI and emergency cases had a higher incidence of 14.89%.
- Most of the cases had SSI detected on 3rd post-operative day.
- Anaemia was found to be the main risk factor for SSIs (23.3%).
- Infection rate was found to be more as the duration of pre-operative hospitalisation increased.
- Prophylactic antibiotic therapy was found to decrease the incidence of SSI's.
- Longer duration of surgery and use of drain was associated with increased incidence of SSI.
- As expected the incidence of SSI was less in clean & clean-contaminated wounds compared to contaminated & dirty wounds.
- SSI caused increased duration of hospital stay.
- E- coli was the commonest organism isolated from SSIs.
- Overall imipenem, meropenem, piperacillin-tazobactum and amikacin were the most effective antibiotics.

CONCLUSION

A pre-existing medical illness, prolonged operating time, the wound class, emergency surgeries and wound contamination strongly predispose to surgical site infection. Antimicrobial prophylaxis is effective in reducing the incidence of post- operative wound infections for a number of different operative procedures but, timing of administration is critical.

Reduction of length of procedures through adequate training of the staff on proper surgical techniques, proper intra-operative infection control measures and feedback of appropriate data to surgeons regarding SSIs would be desirable to reduce the surgical site infection rate.

A surveillance programme for SSI need to be applied by the hospital followed by auditing the infection rate on a regular basis.

Each and every hospital should adopt an antibiotic policy and strict adherence to the same is necessary. Apart from this regular review and monitoring of the implementation of guidelines is equally important.

RECOMMENDATIONS

- The following methods are recommended for further reducing infection.
- Setting up of hospital infection control committee with its members.
- Antibiotic policy and strict adherence to it.
- Regular surveillance and feedback of results to surgeons and following strict surgical auditing.
- Reducing the pre-operative stay to minimum.
- Ensuring that the patient is as fit medically as possible especially in elective cases.
- Minimizing the duration of surgery.
- Using a good surgical technique.
- Avoiding wound drains. If this is not possible, using a closed drainage system and removal of drains as soon as possible.
- Proper collection and transport of samples from the surgical site, immediately on suspicion of infection.
- Awaiting antibiotic sensitivity test results for appropriate antibiotic therapy.

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