Original Article

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A Prospective Study of Postoperative Wound Infections in a Teaching Hospital of Rural Setup

General Surgery Section

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ABSTRACT

Objective: Keeping in view the prevalence of the wound infections in our set up, this study was designed to evaluate the frequency, clinical presentation, common risk factors and the different organisms which were involved in cases of clean and clean-contaminated, contaminated and dirty surgeries

Design and Duration: An observational prospective study from May 2009 to April 2011.

Setting: Surgical Units I and II of the Rajiv Gandhi Institute of Medical Sciences (RIMS), a Govern ment Medical College cum Teaching Hospital in a rural setup in Srikakulam, Andhra Pradesh, India.

Patients: Four hundred and twenty eight patients who underwent clean and clean-contaminated, contaminated and dirty surgeries.

Methodology: The biodata of the patients, together with their clinical features, diagnosis, the type of surgery which was performed and the development of any complications, which included wound infections, was noted and the data was analyzed.

Results: Out of the 428 patients (232 males and 196 females) in the study, 286 belonged to the clean surgery group, 97 belonged to the clean-contaminated surgery group, 27 belonged to the contaminated surgery group and 18 belonged to the dirty surgery group. The overall incidence of surgical site infections (SSI) in this study was 9.81%; 17 (5.94%) cases in the clean surgical group, 9(9.28%) cases in the clean-contaminated group, 6(22.22%) cases in the contaminated group and 10(55.56) cases in the dirty group developed infections. The patients in the age group of 51-60 years were infected more than those in the younger age groups. The inci dence of the wound infections was more in the male patients (11.63%) as compared to that in the female patients (7.65%). Obesity was also a main cause of the SSIs, as was evident from the fact, that the patients with more than 60kg/m2 of weight were infected more (26.7%) as compared to those with 30-40kg/m2 of weight (6.45%). Anaemia, prolonged surgeries, operations which were done by junior surgeons and operations which were late in the list were also associated with more surgical site infections. The usual time of presentation of the SSIs was within three weeks following the surgeries and most of the patients presented with wound abscesses and cellulitis, while nine patients had wound dehiscence. The common organisms which were involved in the SSIs were Staphylococcus aureus, Escherichia.coli and Streptococcus pyogenes.

Conclusion: Meticulous surgical techniques, the duration of the operation, proper sterilization, the judicious use of antibiotics, hygienic operation theatres and ward environments, the control of malnutrition and obesity and the treatment of infective foci and diseases like diabetes help in controlling the morbidity of the surgical wound infections.

Key Words: Surgical Site Infections (SSIs), Post-operative wound Infections, Clean Surgery, Clean-contaminated Surgery, Contaminated Surgery, Dirty Surgery

INTRODUCTION

Until the middle of the 19th century, when Ignaz Semmelweis and Joseph Lister became the pioneers of infection control by introducing anti-septic surgery, most of the wounds became infected. In cases of deep or extensive infections, this resulted in a mortality rate of 70-80% [1]. Since then, a number of significant developments, particularly in the field of microbiology, have made surgeries safer. However, the overall incidence of the healthcare associated infections (HAIs) remains high and it represents a substantial burden of the disease.

In 1992, the US Centers for Disease Control (CDC) revised its definition of 'wound infection', by creating the definition, 'surgical site infection' (SSI) [2], to prevent the confusion between the infection of a surgical incision and the infection of a traumatic wound. Most of the SSIs are superficial, but even so, they contribute greatly to the morbidity and the mortality which are associated with the surgeries [3, 4]. Estimating the cost of the SSIs has proved to be difficult, but many studies have agreed that an additional bed occupancy is the most significant factor.

A major wound infection is seen when a wound discharges pus and it may need a secondary procedure to be sure of an adequate drainage; there may be systemic signs or a delay in returning home. In minor wound infections, there is a discharge of pus or serous fluid without an associated excessive discomfort or systemic signs [5].

A wound infection is the commonest and the most troublesome disorder of wound healing [6]. Post-operative wound infections have been a problem since surgery was started as a treatment modality. The advancement in medicine has resulted in the prevention and the control of this infection. The introduction of anti-septics has been considered to be an important milestone on the route to safe surgeries. The discovery of anti-microbial agents also enables us to perform surgeries in many conditions that were previously thought to be impossible in the pre-antibiotic era, due to the risk

of infections [7]. The infection in a wound is a manifestation of the disturbed host-bacteria equilibrium that is in favour of the bacteria. This not only elicits a systemic septic response, but it also inhibits the multiple processes that are involved in the wound healing i.e. each of these processes is affected when the bacteria proliferate in a wound [8]. A system of classification for operative wounds, that was based on the degree of microbial contamination, was developed by the US National Research Council group in 1964 [9]. Four wound classes with an increasing risk of SSIs were described: clean, clean-contaminated, contaminated and dirty [Table/Fig-1]. The simplicity of this system of classification has resulted in it being widely used to predict the rate of infection after a surgery. A key point in this system is that the classification is directed at the surgical incision, not to the areas around it, even if they have the characteristics which have been included in one or another of the classifications. In other words, the holes which are made by the stitches that close an incision are not included.

The most widely recognized definition of an infection, which is used throughout the USA and Europe, is that which has been devised by Horan and colleagues and which has been adopted by the CDC [2]. This splits the surgical site infections into three groups – superficial and deep incisional SSIs and organ-space SSIs – depending on the site and the extent of the infections. The definitions of superficial and deep infections have been summarized in [Table/Fig-2]. The CDC definition states that only the infections that occur within 30 days of a surgery (or within a year in the case of implants) should be classified as SSIs.

Classification	Criteria
Class I/Clean	Elective, not emergency, non-traumatic, primarily closed; no acute inflammation; no break in technique; respiratory, gastrointestinal, biliary and genitourinary tracts not entered.
ClassII/ Clean-contaminated	Urgent or emergency case that is otherwise clean; elective opening of respiratory, gastrointestinal, biliary or genitourinary tract with minimal spillage (e.g. appendectomy) not encountering infected urine or bile; minor technique break.
Class III/ Contaminated	Non-purulent inflammation; gross spillage from gastrointestinal tract; entry into biliary or genitourinary tract in the presence of infected bile or urine; major break in technique; penetrating trauma <4 hours old; chronic open wounds to be grafted or covered.
Class IV/Dirty	Purulent inflammation (e.g. abscess); pre-operative perforation of respiratory, gastrointestinal, biliary or genitourinary tract; penetrating trauma >4 hours old.

[Table/Fig-1]: Classification of operative wounds based on degree of microbial contamination

PATIENTS AND METHODS

This prospective study was carried out in the Surgical Units-I and II of the Rajiv Gandhi Institute of Medical Sciences (RIMS), a Government Medical College cum Teaching Hospital in a rural setup in Srikakulam, Andhra Pradesh, India, from May 2009 to April 2011, on 418 cases that underwent clean, clean-contaminated, contaminated and dirty surgeries [Table /Fig -3 to 6].

Inclusion Criteria

1. Age >14 years.
2. Patients of either sex.
3. Patients who underwent clean and clean-contaminated surgeries electively and contaminated and dirty surgeries in an emergency. Prophylactic antibiotics were given for the groups of Class II , III and IV at the right time and duration.

Exclusion Criteria

1. Refusal to participate in the study.
2. Patients who were already receiving antibiotics for >1 week.
3. Patients undergoing re-operations.
4. Patients who were failing to come for a follow-up of up to 30 days since the day of the operation.

The relevant information on all the patients was entered on a proforma which was especially designed for the study, which contained details on the biodata, clinical features, the possible risk factors, diagnosis, complications which included wound infections, the organisms which were isolated with their antibiograms, hospital stay and the outcome. The statistics were reported after calculation by using the SPSS, version 10.0 on computer.

Superficial incisional surgical site infections	Deep incisional surgical site infections
Superficial incisional surgical site infections must meet the following two criteria: • occur within 30 days of procedure • involve only the skin or subcutaneous tissue around the incision. *Plus* At least one of the following criteria: • purulent drainage from the incision • organisms isolated from an aseptically obtained culture of fluid or tissue from the incision • at least one of the following signs or symptoms of infection – pain or tenderness, localised swelling, redness or heat – and the incision is deliberately opened by a surgeon, unless the culture is negative • diagnosis of superficial incisional SSI by a surgeon or attending physician The following are not considered superficial SSIs: • stitch abscesses (minimal inflammation and discharge confined to the points of suture penetration) • infection of an episiotomy or neonatal circumcision site • infected burn wounds • incisional SSIs that extend into the fascial and muscle layers (see deep SSIs).	Deep incisional surgical site infections must meet the following three criteria: • occur within 30 days of procedure (or one year in the case of implants) • are related to the procedure • involve deep soft tissues, such as the fascia and muscles. *Plus* At least one of the following criteria: • purulent drainage from the incision but not from the organ/space of the surgical site • a deep incision spontaneously dehisces or is deliberately opened by a surgeon when the patient has at least one of the following signs or symptoms – fever (>38°C), localised pain or tenderness – unless the culture is negative • an abscess or other evidence of infection involving the incision is found on direct examination or by histopathologic or radiological examination • diagnosis of a deep incisional SSI by a surgeon or attending physician.

[Table/Fig-2]: Summary of the definitions of superficial and deep SSIs

Operation	No.	Infected
Excision of Lipoma	36	2
Inguinal Hernia	62	3
Repair of other Hernias (Umbilical, Femoral, Congenital)	32	1
Hydrocele operations	52	4
Trendelenberg operation (Varicose Veins)	11	2
Thyroidectomy	48	2
Excision of Breast lump	16	2
Fibroadenoma of Breast	22	1
Neurofibroma	7	Nil
Total	286	17 (5.94%)

[Table/Fig-3]: Clean operations performed

Operation	No.	Infected
Cholecystectomies	18	2
Nephrectomies	2	1
Hepatic cyst excision	3	-
Resection anastomosis of Intestines	15	3
Pancreatic Pseudocyst	1	-
Appendectomies	26	2
Gastrojejunostomy	9	-
Pyelolithotomy	6	1
Ureterolithotomy	9	-
Cystolithotomy	8	-
Total	97	9(9.28%)

[Table/Fig-4]: Clean-contaminated operations performed

Operation	No.	Infected
Duodenal Perforations	11	-
Gastric Perforation	3	-
Intestinal Perforations	7	3
Intestinal Gangrene	2	2
Abdominal Stab Wounds	4	1
Total	27	6(22.22%)

[Table/Fig-5]: Contaminated operations performed

Operation	No.	Infected
Draining of Abscesses	6	4
Pyocoele	4	3
Intraabdominal abscess	3	1
Appendicular Abscess	3	1
Perinephric abscess	2	1
Total	18	10(55.56)

[Table/Fig-6]: Dirty operations performed

Age	Male	Female	Total	SSI	%
14-25 years	36	28	64	3	4.69
26-40 years	64	52	116	11	9.48
41-50 years	82	76	158	16	10.13
51-60 years	26	22	48	6	12.50
>60 years	24	18	42	6	14.29
Total	232	196	428	42	9.81

[Table/Fig-7]: Age Distribution & Surgical Site Infection

RESULTS

The overall frequency of the surgical site infections was 9.81%. The incidence amongst the clean surgical cases was 5.94% (17 out of 286) [Table/Fig-3], among the clean-contaminated cases, it was 9.28% (9 out of 97) [Table/Fig-4], among the contaminated cases, it was 22.22% (6 out of 27) [Table/Fig-5] and among the dirty cases, it was 55.56% (10 out of 18) [Table/Fig-6].

Age and sex

Out of a total of 232 male patients, 27(11.63%) had SSIs, whilst 15 (7.65%) out of 196 female patients had SSIs. Thus, it could be inferred that males were more prone to operative wound infections. Age of more than 50 years was found to be a risk factor for the Post-operative wound infections, as has been shown in [Table/Fig-7].

Weight and Height

Most of the patients had a Quetelet Index of between 20-30 kg/m2. The obesity was more common in females and a Quetelet index of more than 40 was identified as a risk factor for the Post-operative wound infections [Table/Fig-8].

Anaemia

The pre-operative range of the Haemoglobin levels is shown in [Table/Fig-9]. Pre-operative transfusions were carried out to bring the level of the haemoglobin to at least 10 gms/dl. Inspite of this correction, it was noted that the surgical site infections were more common in patients who had low haemoglobin levels pre-operatively; the more the anae mia was, the more was the incidence of the SSIs.

Duration of the Operation

Most of the operations were completed within 60 min utes. The rate of the surgical site infections was more in the operations that lasted for more than 150 minutes [Table/Fig-10].

The Sequence Number of Patients on an Operation Table and the Seniority of the Surgeons

It was interesting to note that the chances of surgical site infections were less when the patients were operated as the first case on a particular operation table [Table/Fig-11]. The fact that the experience of the operating surgeon affects the outcome and the incidence of the infection, was also highlighted by the study, the rate of the infection being higher in the patients who were operated on by less experienced surgeons [Table/Fig-12].

Category-A = Consultants with a surgical experience of >10 years. (Professors and Associate Professors)
Category-B = Consultants with a surgical experience of >5 years. (Assistant Professors and Senior Registrars)
Category-C = Residents and postgraduates (PGs) with 3 years of experience.
Category-D = House Officers.

The Clinical Features of Wound Infections, which were Noted

The pattern of the wound infections and the common causative organisms have been given in [Table/Fig-13]. The first dressing was changed on the 3rd post-operative day or before, if the patient complained of severe pain in the wound or if there was fever or soakage of the dressing. The time of appearance of the wound

Quetelet Index	No.	SSI	%
11-20 kg/m²	36	2	5.5
21-30 kg/m²	112	8	7.14
31-40 kg/m²	62	4	6.45
41-50 kg/m²	78	8	10.26
51-60 kg/m²	95	8	8.42
> 60 kg/m²	45	12	26.7

[Table/Fig-8]: Obesity & Surgical Site Infection

Hb (gm/dl)	No.	SSI	%
< 08*	25	6	24
08-09*	39	8	20.5
09-10*	36	6	16.7
10-11	88	11	12.5
11-12	134	9	6.72
12-13	56	2	3.57
> 13	50	--	---

[Table/Fig-9]: Haemoglobin level&SSI (*Pre-op.tranefusions to correct anaemia)

Time of presentation of SSI	No.	%
Before first dressing with fever>99.6°F or pain in the wound	12	28.57
Abscess, cellulitis or discharge noted at 1st week postoperatively	13	30.95
Abscess, cellulitis or discharge noted at 2nd week postoperatively	15	35.71
Abscess, cellulitis or discharge noted at 3rd week postoperatively	2	4.76
Abscess, cellulitis or discharge noted at 4th week postoperatively	-	-

[Table/Fig-10]: Time of Presentation of Surgical Site Infection

Operation Time	No.	SSI	%
< 30 mins	6	3	4.35
31- 60 mins	193	16	8.29
61- 90 mins	126	15	11.9
91-150 mins	22	4	18.18
> 150 mins	18	4	22.22

[Table/Fig-11]: Duration of Surgery & Surgical Site Infection

Sequence of Pts.	No.	SSI	%
Patient 1	263	13	4.94
Patient 2	132	21	15.9
Patient 3	33	8	24.24

[Table/Fig-12]: Incidence of SSI according to sequence of patients on operation table

Surgeon	No.	SSI	%
Category-A	96	6	6.2
Category-B	147	11	7.48
Category-C	128	15	11.7
Category-D	57	10	17.54

[Table/Fig-13]: Seniority of Operating Surgeon and Surgical Site Infection

SSI	Common Organisms	No.	%
Wound abscess	Staphylococcus aureus	16	38.09
Localized cellulites	Staphylococcus aureus/ Escherichia coli	7	16.67
Spreading cellulites	Streptococcus pyogenes	3	7.14
Wound dehiscence	E.coli/Klebsiella sps./ Pseudomonas aeruginosa/ Proteus sps.	9	21.43

[Table/Fig-14]: Type of Surgical Site Infection & Organisms

infection was within three weeks following the surgery; no patient presented in the fourth week [Table/Fig-14]. A wound dehiscence appeared in the second post-operative week. No patient developed septicaemia or any other life threatening condition.

Results of the Cultures which were Taken from the Wound

Positive cultures were obtained from the infected wounds. The commonest bacterial isolates were Staph. aureus, Streptococcus pyogenes, Escherichia coli, Klebsiella sps., Pseudomonas aeruginosa and Proteus sps. In certain cases, multiple infections were seen in more than 3 species.

Risk Factors

There were multiple reasons for the post-operative wound infections, which have been validated and documented as the risk factors. A risk factor is any recognized contribution to an increase in the post-operative wound infections.

The Patient

- The patient's age (elderly and neonates)
- The nature of the presenting clinical condition
- Concurrent disease (e.g. diabetes)
- Malnutrition

Surgical Categories

- Operations in contaminated or infected tissues
- Transplant or implant operations

Surgical Procedures

- Poor surgical technique
- Accidental spillage from the bowel
- Excessive use of diathermy
- Long duration of the operation
- Haemorrhage and haematomas
- Use of drains

Pre-operative Patient Care

- Inappropriate antibiotic prophylaxis
- Inadequate skin care

Staff, Theatre Design and Planning

- Staff with skin infections in the theatre
- Unrestricted movement of the staff
- Inappropriate use of the theatre clothing
- Open containers of the solutions (e.g. saline or disinfectants)
- Inadequate operating theatre ventilation
- Simultaneous operations in the same room

Equipment

- Inadequate sterilization/disinfection
- Re-use of inadequately processed invasive devices
- The surgical ward
- Prolonged preoperative stay

- Inadequate training of the nursing and the medical staff
- Inappropriate dressing techniques

DISCUSSION

Despite the advances in the operative techniques and a better understanding on the pathogenesis of the wound infections, Post-operative wound infections continue to be a major source of morbidity and mortality for the patients who undergo operative procedures. Its rate varies in different count ries, different areas and even in different hospitals. Our overall incidence was 9.81%, whereas Ahmad M et al. [10]. Damani described a 30% incidence of hospital-acquired infections [11]. Another study quoted a figure of 40% in all clean and clean-contaminated procedures, which resulted in increased costs and the morbidity of the patient [12]. Silom Jamulitrat et al., [13] noted an overall infection rate of 6.5%. When categorized operation by traditional wound classification, in fections occurred in 3.6% of the clean wounds, 8.4% of the clean-contaminated wounds, 11.8% of the contaminat ed wounds and in 31.0% of the dirty or the infected wounds, which was in accordance with our findings.

The post-operative wound infection rate in our study was 5.94% amongst the clean surgery cases, which was higher, as the usually reported rates varied from 1% to 4%, though most of the studies had documented a rate of less than 2% [14]. Our in fection rate for the clean-contaminated cases was 9.28%. Different studies had shown a range of 5-30% in this class [15]. A study which was conducted at the Mayo Hospital, Lahore, reported an infection rate of 5.05% among the clean and a rate of 8.39% amongst the clean-contaminated cases [16]. Another study which was done by Hernandez [17] in Peru in 2005 described rates of 13 9% and 15.9% amongst the clean and the clean-contaminated cases.

The patients with ages of more than 50 years had a higher incidence (12.5%) of post-operative wound infections in this study as compared to an incidence of 8.6% in the patients who had ages of less than 26 years [Table/Fig-7]. The odds ratio for the surgical wound infections was 1.2 for every 10 years of age [18]. It can be due to multiple factors like a low healing rate, malnutrition, malabsorption, increased catabolic proces ses and a low immunity [19].

Obesity is known to be a well established risk factor for Post-operative wound infections. In this study, a body mass index of more than 40kg/m2 was associated with a higher rate of post-operative wound infections [Table/Fig-8]. Obesity contributed as strongly as the surgical pro cedure category to a patient's likelihood of acquiring a surgical site infection [20].

Anaemia itself is not an established factor for post-ope rative wound infections. However, a higher incidence of post-operative wound infections was noted with the initial low haemoglobin levels [Table/Fig-9]. It can be due to the effect of the blood transfusions which were given pre-operatively to bring the haemoglobin level to upto 10gm/dl. Ford et al., [21] postulated this in 1993.

In our study, 15 (35.71%) patients presented with surgical site infections in the second post-operative week, 13 (30.95%) presented in the first week and 2 (4.76%) presented in the 3rd week [Table/Fig-10]. Twun et al., reported that 92% of their Post-operative wound infections were detected by the 21st day [22], which was comparable to our results. In another study which was done at the Fauji Foundation Hospital, Rawalpindi, most of the cases of wound infections were noticed by the 6th post-operative day [23].

Regarding the duration of the operation, a prolonged time is a significant risk factor for Post-operative wound infec tions [24]. In this study, a higher incidence of Post-operative wound infections was observed when the duration of the opera tion was more than 150 minutes [Table/Fig-11].

An interesting observation was that the infection rate was significantly low when the patients were operated as the first case on a particular table. It was 4.94% for the pati ents who were operated as the first case, it was15.9% for the second case and it was 24.24% for the third case [Table/Fig-12]. The findings of the present study, in this respect, was correlated with the findings of Masood Ahmed et al., [10] as this may be put down to some break in the sterility of the operation room or the instruments due to an increase in the number of microflora of the OT environment due to the persistent movement of the OT staff and the surgical team, besides the fact that senior surgeons usually perform the first cases.

The rates of the post-operative wound infections were higher (17.54%) amongst the patients who were operated by the junior surgeons with lesser experiences than amongst those who were operated by senior surgeons (6.2%) with longer experiences, as has been depicted in [Table/Fig-13]. Mishriki et al., reported increased infection rates with an increased duration of the operation and in surgeries which were performed by junior residents. The rates of the infections with the individual surgeons varied from 3.9 to 14.6% [25]

A simple wound abscess was the common presentation in our cases. Although a wound infection is the commonest cause of dehiscence, only two cases were seen in our series. No case of septicaemia, spreading cellulitis or necrotizing fascitis was noted in this study. A positive culture is not necessary for the diagnosis of a wound in fection [26]. Eighty three percent (35 out of 42) of our cases were cultured and they were re ported as positive. Arora and colleagues [27] quoted a figure of 87% for the positive cultures, whereas Masood Ahmed et al., [10] reported positive cultures for their SSI cases. Staphylococcus aureus was described as the most common single pathogen which was involved in Post-operative wound infections. In our series, this organism was isola ted from 38% cases. Escherichia.coli was the second most common pathogen which was isolated [Table/Fig-14].

CONCLUSION

In spite of the modern surgical and sterilization techniques and the use of prophylactic antibiotics, SSIs are still a real risk in surgeries and they represent a substantial burden of disease both for the patients and the healthcare services in terms of the morbidity, mortality and the economic costs. The changes in the definition have focused attention on the infection of the surgical incision, and the factors which have been associated with the SSIs are now being studied with a view to limiting the risk of the infection.

The common correctable risk factors are malnutrition, obesity, the presence of infective foci, diabetes, hygienic conditions and the duration of the operation. These achievable preventive measures should be taken to save the econo mic burden on the patient, on the hospital and on the community as a whole. The improper and the prolonged use of antibiotics should be avoided, as this can lead to the development of resistant strains of micro-organisms, which can lead to nosocomial infections.

Research has shown that surgical techniques, skin preparations and the timing and the method of the wound closure are the

significant factors that can influence the incidence of the subsequent infections. An antibiotic prophylaxis has also had a positive impact after certain types of surgeries. Many other factors have been identified as having an effect on the potential for infection and healthcare professionals should consider these before, during and after surgeries.

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