COMPARATIVE INFLUENCE OF SUTURE MATERIALS AND RELATED RISK FACTORS ON THE INDUCTION OF SURGICAL SITE INFECTIONS IN SELECTED GYNECOLOGICAL PROCEDURES

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ABSTRACT

Objective: To find out the comparative influence of various suture materials and related risk factors in the development of post-operative surgical site infection.

Methodology: An observational analytical study was conducted retrospectively in Gynae & Obstetric Units of Lady Reading Hospital, Hayatabad Medical Complex & Khyber Teaching Hospital over a period of 4 months (1st February 2013 to 31st May 2013). Overall 45 patients with selected procedures, i.e. total abdominal hysterectomy, lower segment caesarean section (LSCS), laparoscopy, burch colposuspension & Fothergill repair using only specific suture materials i.e. black silk, polypropylene, polyglactin 910 & chromic catgut, were included in the study. The data was analysed using GraphPad Prism (GraphPad Software Inc. San Diego CA, USA).

Results: Out of the total 45 cases, the procedure that resulted in most surgical site infections was emergency lower segment caesarean section (LSCS) followed by total abdominal hysterectomy. The suturing materials resulted in the development of surgical site infection in an order of black silk ≥ polypropylene ≥ polyglactin 910. Among the identified pathogens, *Staphylococcus* ranked higher than others. Resuturing of the wounds with similar material as initial resulted in more pervasiveness of reinfection.

Conclusion: Black silk resulted in most pathogenic surgical site infections, followed by polypropylene and polyglactin 910.

Key Words: Surgical site infection, Sutures, Black silk, Lower segment caesarean section, Total abdominal hysterectomy

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INTRODUCTION

According to the National Institute for Health and Clinical Excellence Guidelines, a surgical site infection (SSI) is a type of healthcare associated infection in which a wound infection occurs after an invasive procedure[1]. SSIs are the third most common nosocomial infections reported in hospitalized patients which account for 14-16% of all hospital acquired infections[2]. Due to these infections, patients suffer financially ($ 2,000 per day) and their stay in the hospital is also prolonged (at least 10 days) [3-4].

The Centre for Disease Control (CDC) has described the SSIs as being incisional SSI and organ/space SSI. The former comprise only the skin and subcutaneous tissue (superficial incisional SSI) and deep soft tissues (deep incisional SSI). The later encompasses any anatomical part (other than the incision) exposed or handled during the surgical procedure[5-6].

CDC's Guidelines for prevention of SSIs divided surgical wounds into 4 main classes namely clean, clean-contaminated, contaminated and dirty-infected depending upon the signs each of them is exhibiting[7-8]. The risk associated with the development of SSIs in each wound class varies, ranging from <2% in clean wounds to about 10%, 13% and 40% in clean-contaminated, contaminated and dirty-infected wounds respectively[9]. For most SSIs, the source of pathogens is the endogenous flora residing in the patient's skin, mucous membranes or hollow viscera[10]. Procedures involving female repro-

ductive tract are considered clean-contaminated, i.e. normal flora of the vagina is presumed to contaminate the wound[7-8]. Distribution of pathogens among SSIs in data from NNIS for the years 1986 through 1996, shows the most frequent pathogen to be *Staphylococcus aureus*[11]. In quantitative terms, it has been shown that if a surgical site is contaminated with $>10^5$ microorganisms per gram of tissue, development of an SSI is most likely[12]. However, the dose of microorganisms required to produce infection reduces many folds in the presence of a foreign material for example sutures (i.e. 100 *Staphylococci* per gram tissue introduced on a silk suture)[13-15].

Unfortunately, there is no decisive data on the incidence of SSIs directly associated with sutures or their chemical nature, but it is reasonable to assume that a substantial proportion of SSIs involves sites containing suture materials[16]. It is now accepted widely that suture material provides a platform for microbial adherence and wound contamination. Literature review reveals that bacterial adherence to suture depends on the microbial species and the suture composition and structure. This even if addressed before handling (such as by preoperative skin preparation or antimicrobial prophylaxis), still poses a huge threat because of the antimicrobial resistance associated with the most common pathogens i.e. staphylococci and enterococci[17-20]. This study was conducted to find out the comparative influence of various suture materials and related risk factors in the development of post-operative surgical site infections.

METHODOLOGY

Approval for data collection was taken from the respective authorities of each of the 3 hospitals as well as from the Department of Pharmacy, University of Peshawar. A verbal consent was taken from the patients with the assured confidentiality of their identity. The declaration of Helsinki[21] was strictly followed during data collection. The study was conducted in Gynae and Obstetrics Units of the 3 major hospitals of Peshawar, namely; Lady Reading Hospital, Hayatabad Medical Complex and Khyber Teaching Hospital, over a period of 4 months from 1st February 2013 to 31st May 2013. The study comprised of 45 cases in which the patients developed surgical site infections.

Only patients who underwent selected procedures i.e. total abdominal hysterectomy, lower segment C/section, laparoscopy, burch colposuspension & Fothergill repair, using only selected suture materials i.e. black silk, polypropylene, polyglactin 910 & chromic catgut for abdominal skin closure were included in the study. Patients included were all females, above the age of 14, presented with all or any sign of infection within 1 week of surgery & willing to come for follow-up of up to 20 days from the day of surgery. Those patients who did not meet the above criteria i.e. presenting with signs of infection after 1 week of surgery, and/or in which electric e.g. commercially available electrical stimulation devices for wound healing and/or mechanical e.g. skin stapler were used for skin closure, were all excluded.

Suture material was chosen as a direct parameter whereas the co-existing risk factors such as obesity, age and other comorbidities were the indirect parameters, in contrast to the parameters defined by CDC's Guidelines for prevention of SSIs, and its influence was compared towards induction of an infection. Data were evaluated on the basis of results obtained from culture sensitivity of the specimen collected from the vicinity of infected area using sterile swab stick and testing it in accordance with clinical and laboratory standard institute guidelines[22]. The presence or absence of microbial growth, relation of these microbes with primary & secondary inducers (direct& indirect parameters) of infection and sensitivity of these microbes towards different antibiotics were recorded. All information was recorded on a pre-designed structured proforma. Statistical analysis (frequency, percentage, ratio, range and mean/SD) was employed for variables of interest. Data storage, processing and analysis was done utilizing SPSS version 21.0. Data was presented in the form of tables and figures.

RESULTS

Out of the total 45 clean-contaminated surgeries, the most frequent surgery that resulted in most infections was lower segment caesarean section (LSCS) (42.22%), followed by total abdominal hysterectomy (33.33%). The most common suture was the black silk (48.88%), followed by polypropylene and polyglactin 910 (15.55% each). (Table 1)

Culture test was performed for all the cases of SSIs for the identification of microbial growth, if any. In 60% of the cases, no growth was observed; while in rest of the cases, 11.11% were mixed growth (MRSA/E. Coli or Staphylococcus Aureus/Acinetobacter Spps.). The frequency of identified pathogens is shown in table 2. Sensitivity test provided information about the antibiotics towards which the identified pathogen was sensitive, partial sensitive or resistant. Patients with positively identified pathogens were then started on their respective sensitive antibiotic immediately after obtaining the results of sensitivity test. The culture sensitivity test data revealed the antibiotics to which the pathogens showed the highest sensitivity were vancomycin (gram +ve) and Meropenem (gram –ve). The results are summarized in Table 3, including their spectrum of activity.

Out of 39.99% obtained positive microbial growth, the frequency of each pathogen in relation with the suture material used in the surgery is summarized in Table 4. Most frequent among all was the black silk which

nailed most pathogenic SSIs (22.5%); whereas chromic catgut did not result in any pathogenic growth. As a management strategy, as per the ward protocol, wound debridement and frequent resuturing of the surgical site was also performed in addition to starting the patient on their respective sensitive antibiotic (Figure 1-3). In our study, incision was resutured in 80% cases whereas in 20 % cases, no resuturing was done. Out of the 80% resutured cases, 61.11 % resuturing was done with different suture material than the initial one used and 38.9% resuturing was done with the same material as that of the initial one. Percent projected prevalence of reinfection is shown in table 5. Additional risk factors studied as secondary contributing agents towards induction of SSIs for the purpose of this study are summarized in Table 6. The values against each risk factor represent the obtained results in comparison to the total sample size.

Table 1: Frequency of usage of each suture material (size wise) in total sample (n=45)

Suture Material	Frequency	Percentage
Black Silk 2/0	22	48.88%
Polypropylene 4/0	6	13.33%
Polypropylene 1/0	7	15.55%
Proglactin 910 2/0	7	15.55%
Black Silk ¼	1	2.22%
Chromic Catgut 1/5	1	2.22%

Table 2: Distribution of identified pathogens according to culture sensitivity test results

Microbial Growth	Frequency	Percentage
No Growth	27	60%
E. Coli	3	6.66%
Coliform Spps.	2	4.44%
Staphylococcus Aureus	4	8.88%
MRSA	3	6.66%
Psuedomonas Aeruginosa	1	2.22%
Mixed Growth	5	11.11%
Total	45	100%

Table 3: Spectrum of activity of different antibiotics and antimicrobial agents in positively identified microbial cultures

Name of the drug	Gram +ve		Gram -ve			
	Staph. Aureus	MRSA	Coliform Spps.	E. Coli	Acinetobacter Spps.	Pseudomonas
Vancomycin	**	***	*	-	-	-
Meropenem	*	-	***	****	-	**
Teicoplanin	*	**	-	-	-	-
Linezolid	*	**	-	-	-	-
Imepenem	*	-	***	****	-	**
Cefoperazone/Sulbactam	*	-	*	**	*	*
Amikacin	*	-	*	**	-	*
Fusidic Acid	*	**	-	-	-	-
Pippercillin/Tazobactam	-	-	**	***	-	*
Chloramphenicol	**	***	-	*	-	-
Clindamycin	*	**	-	-	-	-

Note: **** > *** > ** > * - = No activity

Table 4: Suture material and microbial growth frequency

Identified pathogen	Obtained Pathogens in relation to Suture material			
	Polypropylene (1/0, 4/0, 2/0)	Black Silk (2/0, 1/4)	Proglactin 910 (2/0, 2/5)	Chromic Catgut (1/5)
E. Coli	1	2	-	-
Staphylococcus Aureus	1	1	2	-
MRSA	2	1	-	-
Coliform Spps.	-	1	1	-
Pseudomonas Aeruginosa	-	1	-	-
Mixed Growth	2	3	-	-
Total	6 (15%)	9 (22.5%)	3 (7.5%)	0 (0%)

Table 5: Projected prevalence of reinfection

Relationship of prevalence of re-infection to the resuturing material	
Resuture material	**% Prevalence**
Same	21.43%
Different	13.63%

Table 6: Indirect/secondary contributing parameters

Risk factors	Percentage
Age: ≥ 45 years	28.88%
Obesity: BMI >29	37.77%
Pre-operative Hair Removal	
Using razor	48.88%
Using Cream	13.33%
Not removed	37.77%
Bath after Operation	
Yes	24.44%
No	75.55%
Wound Care	
Followed Instruction	46.66%
Not followed Instruction	28.88%
Comorbidities	
Hypertension	8.88%
Diabetes	6.66%
Pregnancy Induced Hypertension	15.55%
Gestational Diabetes	4.44%
Hospital Acquired Respiratory Infection	2.22%
Literacy (Understanding wound care plan during home stay)	
Yes	57.77%
No	15.55%

Figure 1: Patient presented with reinfection on 5th post resuturing day. Suture material used in initial and post debridement surgery was polypropylene

Figure 2: Patient on 6th post-operative day, presented with pus discharge. Suture material used was polyglactin 910

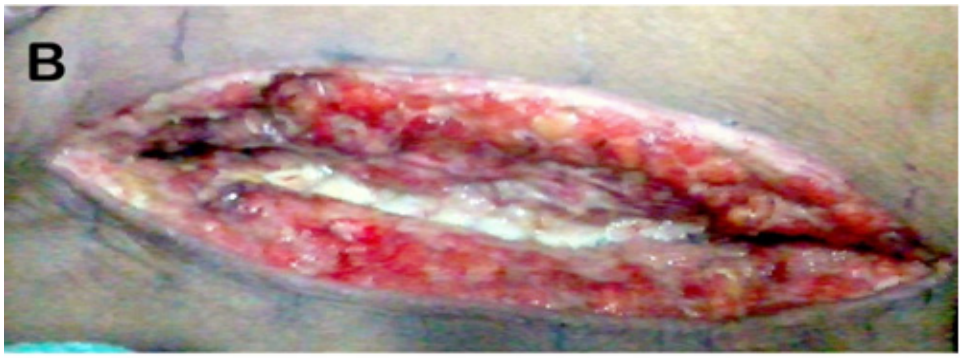
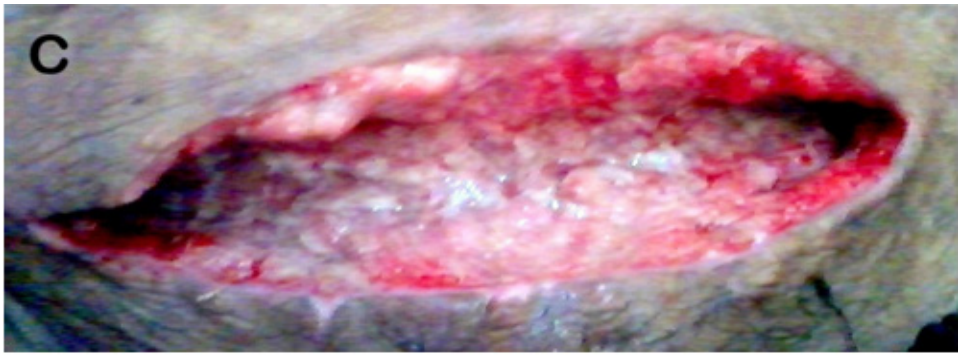


Figure 3: Post debridement image of patient. Suture material used was black silk



DISCUSSION

Surgical site infection is caused by microbial contamination of the surgical wounds. Host's defense system tries to combat but if it is overwhelmed by the number and virulence of the microorganisms such as bacteria and fungi, an infection presents itself. Typically, $>10^5$ microorganisms per gram of tissue are required to be present for an infection to develop, unless foreign material is present in the surgical site such as sutures or mesh etc.[22].

The adherence of bacteria to various sutures has been investigated, and variations in adherence affinity are correlated with infection. For example, the number of bacteria needed to establish infection can be reduced many folds by the presence of a silk suture. In this study, the incidence of infection in the presence of silk sutures (black silk 2/0 & 1/4) was found to be 51% as compared to polypropylene or Polyglactin 910. Similar results were also established in a comparative study, where silk sutures were tested against polyglycolic acid sutures for

their inflammatory response in oral environment. The inflammatory reaction of gingival tissues was lower for polyglycolic acid suture compared to silk sutures[23].

Henry-Stanley et al concluded in their study that bacterial growth on suture materials has characteristics of biofilm formation[24]. Distribution of these pathogens in a biofilm depend upon many factors such as chemical nature of the suture, filament configuration (monofilament or braided) and nature of coating material (absorbable or non-absorbable)[19]. Henry-Stanley et al provided some established results that black silk (braided, non-absorbable) had preferential bacterial adherence as compared to monofilament/absorbable sutures[24]. Our study seconds this finding. On the contrary, some studies have successfully demonstrated polyglactin 910 to have higher susceptibility towards bacterial adherence and hence inducing SSIs[25-26].

Up till now, no such attempt has been made to substantiate the role of suture material towards the induction of surgical site infection by resuturing the incision site. We, in our research studied this fact. When different suture material than initially used in primary surgery, was used for resuturing, the prevalence of reinfection was reduced to only 13.61% whereas it was 21.43% in case of same suture material which was used initially. It is tempting to speculate that resuturing after debridement with a different suture material than initial provides an added benefit for reduction in surgical site infections. Further studies are required to validate these findings.

CDC's guidelines and some studies[26] show that the risk of developing SSIs is greater with increasing age. In this study, patients equal to or greater than 45 years of age resulted in overall 28.88 % of SSIs in the study sample. Studies conclude that with increasing age, population becomes more prone to higher degree of wound contamination, diminished or altered response to pathogens, malnutrition, chronic diseases and inadequate cardiac output[27].

Many studies have validated obesity in particular, as one of the risk factors among patients undergoing major abdominal surgeries and suggested pathophysiology of obesity related to SSIs (decreased wound oxygen tension, impaired tissue antibiotic penetration, altered immune function, etc.). However, the true effect of obesity has not yet been clearly described[28]. In our study, 37.77% frequency was observed. 17 patients with BMI >29 showed longer healing and management time compared with normal weight patients.

In 2007, a review of eleven randomized controlled trials was conducted to determine if routine preoperative hair removal results in fewer surgical site infections than not removing hair at all[29]. It concluded that there is insufficient evidence to state whether removing hair impacts surgical site infection or when is the best time to remove hair; however, if it is necessary to remove hair, then both clipping and depilatory creams result in fewer SSIs than shaving with a razor. It has been further demonstrated that using a disposable razor and shaving the incision site prior to surgery resulted in 48.88% SSIs as compared to 37.77% SSIs of no hair removal. The least preponderance was observed with usage of hair removing cream i.e. 13.33%.

Patients living in rural areas with poor facilities and literacy rates developed SSIs with a double frequency (32 times compared to 13 times) than those living in urban areas. Additionally, every patient was advised to apply povidone iodine dressing at least 2 times daily after the initial operation before the stitches were taken out. They were advised to clean the site using gauze soaked in antiseptic and gently tap the site and not rub it. regarding adherence to these instructions, 46.66% patients followed the exact procedure while 28.88% were non-complaint. Patients were directed for taking bath with approximately 30 ml povidone iodide added to bath water, only 24.44% followed the instructions while 75.55% did not follow.

According to the CDC guidelines, patients with diabetes are more prone towards developing SSIs, however similar patterns of risk of SSIs were also observed in cases of other diseases like hypertension, gestational diabetes, pregnancy induced hypertension and different combination diseases in our study.

Our study allowed us to extensively observe different resistance and sensitivity patterns of antibiotic towards the obtained microbes. The drugs against which increased resistant was developed included cefotaxime, ciprofloxacin, ceftriaxone, levofloxacin, cotrimoxazole and gentamicin, whereas the most sensitive drugs were vancomycin, meropenem, imepenem, amikacin, fusidic acid, linezolid, teicoplanin, pippercillin/ tazobactam and cefoperazone/ sulbactam. Overall antibiotic resistance is one of the major factors of prophylaxis failure and prolonged treatment duration. Major cause for the development of resistance is the easy availability of these drugs and hence the irrational usage.

We conclude that the overall incidence of 51% of surgical site infections can be attributed to the usage of black silk suture (black silk 2/0 48.88%, black silk ¼ 2.22%), followed by polypropylene and polyglactin 910. However, further studies are encouraged to establish this relation. Antibiotic prophylaxis failure is also a contributing factor; whereas topical use of the antibiotics has proven to be more effective. That is why, the use of antibiotic coated sutures frequently as common practice could decrease or reduce the chances of development of SSIs.

The common correctable risk factors were obesity,

pre-operative hair removal, hygienic conditions and compliance with the instructions of the doctor. Physicians and practitioners specializing in respective comorbid diseases should be involved in overall patient for pre-surgery prophylaxis and post-surgery wound care. These achievable preventive measures should be taken to save the economic burden on the patient, hospital and the community as a whole. Improper and prolonged use of antibiotics should be avoided as it can lead to the development of refractory strains of micro-organisms.

CONCLUSION

Black silk results in most pathogenic surgical site infections, followed by polypropylene and polyglactin 910.

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CONTRIBUTORS

SA Conceived the idea and final revision of the manuscript. TS provided the sample and co- supervised the study. TM and USU helped manuscript writing. NA helped manuscript writing and statistical analysis. AR helped Study design and proof reading. S supervised the study. All authors contributed significantly to the submitted manuscript.