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CLINICAL & BASIC RESEARCH

A Study of Post-Caesarean Section Wound Infections in a Regional Referral Hospital, Oman

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دراسة عدوى الجروح لما بعد الولادة القيصرية في مستشفى إحالة إقليمي، عمان

هانسا دهار، إبراهيم البوسعيدي، وبهاونا راثي،وإيمان اليون نمر،فيبها ساشديفا،إلهام حمدي

ABSTRACT: ***Objectives:*** The aim of this study was to determine the incidence of surgical site infections (SSI) in patients undergoing a Caesarean section (CS) and to identify risk factors, common bacterial pathogens and antibiotic sensitivity. SSI significantly affect the patient's quality of life by increasing morbidity and extending hospital stays. ***Methods:*** A retrospective cross-sectional study was conducted in Nizwa Hospital, Oman, to determine the incidence of post-Caesarean (PCS) SSI from 2001 to 2012. This was followed by a case-control study of 211 PCS cases with SSI. Controls (220) were randomly selected cases, at the same hospital in the same time period, who had undergone CS without any SSI. Data was collected on CS type, risk factors, demographic profile, type of organism, drug sensitivity and date of infection. ***Results:*** The total number of PCS wound infections was 211 (2.66%). There was a four-fold higher incidence of premature rupture of the membranes (37, 17.53%) and a three-fold higher incidence of diabetes (32, 15.16%) in the PCS cases compared with controls. The most common organisms responsible for SSI were *Staphylococcus aureus* (66, 31.27%) and the Gram-negative *Escherichia coli* group (40, 18.95%). The most sensitive antibiotics were aminoglycoside and cephalosporin. Polymicrobial infections were noted in 42 (19.90%), while 47 (22.27%) yielded no growth. A high incidence of associated risk factors like obesity, hypertension, anaemia and wound haematoma was noted. ***Conclusion:*** Measures are recommended to reduce the incidence of SSI, including the implementation of infection prevention practices and the administration of antibiotic prophylaxis with rigorous surgical techniques.

Keywords: Caesarean Section; Surgical Wound Infections; Wounds and Injuries; Antibiotics; Risk Factors; Nosocomial Infections; Oman.

الملخص: **الهدف**: تهدف هذه الدراسة إلى تحديد معدل انتشار العدوى في الموقع الجراحي للمرضى اللواتي أجريت لهن عمليات قيصرية، وتحديد عوامل الاختطار ومسببات الأمراض البكتيرية الشائعة وحساسية المضادات الحيوية. انتشارالعدوى في الموقع الجراحي له تأثير كبير على نوعية الحياة للمرضى عن طريق زيادة المراضة وتمديد الإقامة في المستشفى. **الطريقة**: أجريت دراسة استعادية مستعرضة في مستشفى نزوى، عمان، لتحديد مدى انتشار عدوى جرح الولادة القيصرية من 2001 إلى 2012. أتبعت هذة الدراسة بدراسة لمراقبة 211 حالة من العمليات القيصرية المصابة بالتهاب الجرح الجراحي. المجموعة المرجعية (220) من الحالات التي تم اختيارها عشوائياً لمن أجريت لهن عمليات قيصرية من دون حدوث التهاب الجرح الجراحي في نفس المستشفى ولنفس الفترة الزمنية. شملت البيانات التي تم جمعها تفاصيل نوع العملية القيصرية، وعوامل الاختطار، التوزيع الديموغرافي ، نوع الميكروب المسبب وحساسية العقاقير و يوم ظهور العدوى من تاريخ عمل القيصرية. **النتائج**: كان العدد الإجمالي لعدوى جرح القيصرية 211 (2.66%). ووجد أن هناك أربعة اضعاف الزيادة في حالات الإصابة بالتمزق المبكر للأغشية (37، 17.53%) وثلاثة أضعاف الزيادة في السكري (32، 15.16%) من حالات بعد العمليات القيصرية مقارنة بالمجموعة المرجعية. الميكروب الأكثر شيوعاً المسؤول عن عدوى الجرح كان العنقودية الذهبية (66، 31.27%)، والإشريكيّة القولونية سلبية الغرام (عدد= 40، 18.95%). ووجد أن أكثر المضادات الحيوية حساسية هي الأمينوغليكوزيد و السيفالوسبورين. لوحظ أن إصابة الجرح متعدد الميكروبات وجد في 42 (19.90%) وأنه في 47 (22.27%) لم يوجد أي نمو بكتيري. لوحظ أنه يوجد نسبة عالية من عوامل الاختطارالمرتبطة بعدوى الجرح القيصرى مثل السمنة وارتفاع ضغط الدم وفقر الدم والورم الدموي. **الخلاصة**: التدابير الموصى بها والتي من شأنها التقليل من الإصابة بعدوى الموقع الجراحي تشمل تنفيذ ممارسات الوقاية والاتقاء بالمضادات الحيوية مع تقنية جراحية جيدة.

مفتاح الكلمات: العمليات القيصرية؛ عدوى الجرح الجراحى؛ الجروح والإصابات؛ المضادات الحيوية؛ عوامل الاختطار؛ عدوى المستشفيات؛ عمان.

Advances in Knowledge

- *The results of this retrospective study revealed that obesity, diabetes, prolonged labour with premature rupture of the membranes and wound haematoma were the main contributory risk factors for post-Caesarean section wound infections in an Omani regional referral hospital.*
- *The commonest infections were nosocomial infections, particularly hospital-acquired infections. The commonest bacteria grown were Staphylococcus aureus and Escherichia coli sensitive to the cephalosporin and aminoglycoside drug classes.*

Application to Patient Care

- *Surgical site infections have a clinical and economic impact by significantly increasing maternal morbidity and prolonging hospital stays. The results of this study emphasise the need to implement infection control policies. Antibiotic prophylaxis, improved surgical techniques, sterilisation of medical equipment, proper personal hygiene and hand-washing on the part of the hospital staff, as well as*

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post-discharge surveillance programmes for obstetric cases, are recommended to prevent nosocomial infections among women having a Caesarean section.

Caesarean section (CS) wound infections represent a substantial burden to the health system and the prevention of such infections should be a healthcare priority in developing countries.[1] The global estimates of surgical site infections (SSI) are from 0.5–15%.[2] SSI can be attributed to a perioperative bacterial load in the tissue at the site of surgery and the diminished integrity of the host's defenses.[3] Some of the risk factors observed for CS wound infections are obesity, diabetes, immunosuppressive disorders, chorioamnionitis, a previous Caesarean delivery, certain medications like steroids, the lack of pre-incision antimicrobial care, lengthy labour and surgery.[4,5] Any infection of the abdominal wound complicating CS should be minimised through strict preventative measures, such as antisepsis, preoperative preparation, a reduction in the duration of surgery, a reduction in blood loss, the use of absorbable sutures and avoiding cross-infection. Many studies have proved that antimicrobial prophylaxis is effective in reducing the incidence of postoperative wound infections as it reduces the risk of resident bacteria overcoming the immune system in the immediate postoperative period.[6–8]

As infection continues to be a common postoperative complication in both the developed and developing world, there is a need to implement SSI surveillance during and after surgeries so as to obtain a standardised incidence.[9] The delivery of high-quality services with early interventions to reduce wound infections is an important aspect of patient safety measures. Therefore, the aim of this study was to determine the incidence of SSI in patients undergoing a CS at a regional referral hospital in Oman, and to identify risk factors, common bacterial pathogens and antibiotic sensitivity.

Methods

This retrospective cross-sectional study included all post-Caesarean (PCS) wound infections recorded from 2001 to 2012 at the Nizwa regional referral hospital, Oman. Nizwa Hospital provides tertiary care service to all extended hospitals and health centres in the Al Dakhiliyah Governorate, a region in northern central Oman. Wound infections were defined as inflammation or sepsis with or without positive bacterial cultures. With SSI, there may be fever, redness, swelling and/or pain in the area around the incision site. The Centers for Disease Control and Prevention (CDC) state that SSI should be suspected within 30 days of a surgical procedure if at least one of the following symptoms are present: localised swelling, with or without purulent discharge from the wound, pain or tenderness, redness, malodour or fever.

Data concerning all patients with wound infections after a CS procedure from 2001 to 2012 were retrieved from the electronic patient records system of the hospital. This formed the study group (n = 211). Inclusion criteria included infections occurring within 30 days of the surgery which involved the skin, subcutaneous tissues and the *fascia* and muscle layers of the incision site. The cases diagnosed with wound infections during their hospital stay accounted for 62 (29.38%) patients. The remaining 149 (70.61%) patients were readmitted 6–10 days after discharge, with evidence of wound induration and soakage, either with or without fever.

A case-control study was then undertaken of the 211 PCS cases with wound infection. The control group (220) consisted of PCS cases randomly selected during the same period, who were routinely discharged on their third postoperative day without any symptoms of wound infections. All patients with wound infections underwent swab cultures in accordance with hospital policy and all cases of suspected SSI had swabs taken prior to the commencement of antibiotics. Both culture-positive and -negative cases were included in the study. Where the culture was positive, an antibiotic sensitivity tests of the organism was carried out using standard microbiology techniques. The wound swabs of the culture-negative cases yielded no organism growth of any kind after 24 hours of incubation.

The cases and controls were reviewed in detail with respect to the type of CS, the characteristics of the antecedent labour, the duration of the rupture of membranes and other associated risk factors. The organisms isolated from the incision sites were investigated and antibiotic sensitivity was measured. Data collected included details of the wound infections, any organisms grown in the cultures, the drug sensitivity of those organisms as well as the risk factors contributing to infections, like obesity, premature rupture of the membranes (PROM), prolonged labour and comorbid medical conditions like diabetes, hypertension and anaemia. A *P* value of 0.05 or less was considered statistically significant. Ethical clearance was obtained from the Nizwa Hospital Ethical Committee.

Table 1: Total Caesarean section procedures and surgical site infections in Nizwa Hospital between 2001 and 2012 (N = 7,923)

Year	Deliveries per annum	Total CS	SSI	Elective CS	SSI	Emergency CS	SSI
		n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
2001	2,557	240 (9.38)	8 (3.33)	32 (13.33)	3 (1.25)	208 (86.66)	5 (2.08)
2002	2,831	349 (12.32)	14 (4.01)	59 (16.90)	6 (1.71)	290 (83.09)	8 (2.29)
2003	3,191	427 (13.38)	11 (2.57)	109 (25.52)	7 (1.63)	318 (74.47)	4 (0.93)
2004	3,218	464 (14.41)	11 (2.37)	127 (27.37)	7 (1.50)	337 (72.62)	4 (0.86)
2005	3,679	497 (13.50)	8 (1.60)	160 (32.19)	2 (0.40)	337 (67.80)	6 (1.20)
2006	4,014	631 (15.71)	25 (3.96)	175 (27.73)	13 (2.06)	456 (72.26)	12 (1.90)
2007	4,090	618 (15.11)	14 (2.26)	194 (31.39)	6 (0.97)	424 (68.60)	8 (1.29)
2008	4,486	748 (16.67)	12 (1.60)	198 (26.47)	6 (0.80)	550 (73.52)	6 (0.80)
2009	4,989	930 (18.64)	18 (1.93)	255 (27.41)	9 (0.96)	675 (72.58)	9 (0.96)
2010	5,022	896 (17.84)	27 (3.01)	267 (29.79)	13 (1.45)	629 (70.20)	14 (1.56)
2011	5,268	998 (18.98)	37 (3.70)	284 (28.45)	10 (1.00)	714 (71.54)	27 (2.70)
2012	5,409	1,099 (20.31)	26 (2.36)	281 (25.56)	10 (0.90)	818 (74.43)	16 (1.45)
Cumulative totals	**48,754**	**7,923 (16.25)**	**211 (2.66)**	**2,141 (27.11)**	**92 (1.16)**	**5,756 (72.88)**	**119 (1.50)**

CS = Caesarean section; SSI = surgical site infections.

Results

This retrospective case-control cross-sectional study showed the incidence of wound infections in PCS cases in a regional hospital. A cumulative total of 7,923 CS surgeries were performed from 2001 to 2012 in Nizwa Hospital [Table 1]. PCS wound infections occurred in 211 (2.66%) cases and were confirmed by positive bacteriology in 164 (77.72%) cases. The highest rate of infections during these years was 4.01%. Overall, 149 (70.61%) women were diagnosed with wound infections following discharge. A higher infection rate was noted in emergency (119, 1.50%) in comparison with elective (92, 1.16%) CS procedures.

A comparison of the case and control groups for pre-existing risk factors can be seen in Table 2. A calculation of the odds ratio showed that those women who already had more than six children were 1.4 times more likely to contract a wound infection compared to those women who were delivering for the first time or had only one child. However, the association between wound infections and parity was not significant (P = 0.077). Women with diabetes were three times more likely to develop wound infections and the association between diabetes and wound infections was significant (P = 0.001). A four-fold increase was noted in the rate of PROM among the case group compared to the rate among controls. The association between PROM and wound infections was highly significant (P <0.001). The risk of wound infections among those women who were mildly, moderately or severely anaemic was higher compared to those without anaemia and the association with wound infections was significant (P = 0.035). Calculating the odds ratio showed that those women who had hypertension and pre-eclampsia were three times more likely to develop a wound infection compared to women without these conditions. There was a significant association between hypertension, pre-eclampsia and wound infections (P = 0.007). Likewise, women who were morbidly obese, with a body mass index (BMI) of >35, were three times more likely to develop a wound infection compared to non-obese women and the association was significant (P = 0.018).

The majority of SSI cases yielded growth of *Staphylococcus aureus* (66, 31.27%) followed by *Escherichia coli* (40, 18.95%) [Table 3]. Polymicrobial infections were found in 42 (19.90%) cases. The main organisms found to be growing together were: *Klebsiella* and *E. coli*; *Klebsiella* and *Proteus*; *Klebsiella* and *S. aureus*; *E. coli* and coagulase-negative *Staphylococcus*, and *E. coli* and *Proteus*. A few cultures yielded the growth of organisms such as *Morganella morganii*, *Acinetobacter* and methicillin-resistant *S. aureus* (MRSA). There were 47 (22.27%) cases where the culture did not yield any organisms. This was probably due to the use of broad-spectrum antibiotics prior to the wound swab; however, other features of SSI were present, such as wound soakage, induration and sepsis.

The aminoglycoside drug class constituted the most sensitive antibiotic and was used whenever indicated by the culture sensitivity [Table 4]. Cephalosporin is frequently used in Nizwa Hospital as it is the second most sensitive antibiotic of choice and also the most convenient one. Quinolone, like ciprofloxacin, is the least used drug class in the antenatal and postpartum period, followed by combined amoxicillin and

Table 2: Comparison of pre-existing risk factors between the study and control groups of Caesarean section patients (N = 431)

Characteristics		Study group (N = 211) n (%)	Controls (N = 220) n (%)	OR (95% CI)	*P* value
Parity	**0–1**	60 (28.43)	44 (20.00)	1.0	0.077
	2–5	97 (45.97)	122 (55.45)	0.58 (0.36–0.93)	
	≥6	54 (25.59)	54 (24.54)	1.4 (0.79–2.34)	
Diabetes mellitus	**No**	179 (84.83)	208 (94.54)	1.0	0.001*
	Yes	32 (15.16)	12 (5.45)	3.09 (1.55–6.19)	
PROM of ≥6 hours duration	**No**	174 (82.46)	208 (94.54)	1.0	<0.001*
	Yes	37 (17.53)	10 (4.54)	4.46 (2.16–9.20)	
Anaemia	**Normal**	173 (81.99)	198 (90.00)	1.0	0.035*
	†Mild to moderate	27 (12.79)	20 (9.09)	1.52 (0.82–2.82)	
	‡Severe	10 (4.73)	02 (0.90)	5.09 (1.08–23.88)	
HTN/Pre-eclampsia	**No**	191 (90.52)	213 (96.81)	1.0	0.007*
	Yes	20 (9.47)	07 (3.18)	3.19 (1.30–7.70)	
BMI of >35	**No**	193 (91.46)	213 (96.81)	1.0	0.018*
	Yes	18 (8.53)	07 (3.18)	2.83 (1.16–6.94)	

*OR = odds ratio; CI = confidence interval; PROM = premature rupture of the membranes; HTN = hypertension; BMI = body mass index. *Significant; †Haemoglobin levels of 7–10 g/dL; ‡Haemoglobin levels of ≤6 g/dL.*

clavulanate, which was not used at all due to the risk of neonatal side-effects, particularly for preterm cases. Few cases were sensitive to the antipseudomonal penicillin group of drugs, for instance tazobactam and piperacillin. Antibiotics like meropenem and imipenem were used for the *Enterobacteriaceae* which were highly resistant to cephalosporin (*E. coli*, *Klebsiella* and *Enterobacter*).

Table 3: Organisms causing Caesarean section wound infections in the study group (N = 211)

G+	n (%)	G-	n (%)	Other	n (%)
S. aureus	66 (31.27)	*E. coli*	40 (18.95)	No growth	47 (22.27)
MRSA	3 (1.42)	*Klebsiella*	19 (9.00)	Mixed growth*	42 (19.90)
α-H *streptococci*	3 (1.42)	*P. aeruginosa*	18 (8.53)		
β-H *streptococci*	1 (0.47)	*Enterobacter*	5 (2.36)		
		Proteus	3 (1.42)		
		G- *bacilli*	1 (0.47)		
		M. morganii	1 (0.47)		
		Acinetobacter	1 (0.47)		
		ESBLP *E. coli*	3 (1.42)		

*G+ = Gram-positive organisms; G- = Gram-negative organisms; S. aureus = Staphylococcus aureus; E. coli = Escherichia coli; MRSA = methicillin-resistant staphylococcus aureus; H = haemolytic; P. aeruginosa = Pseudomonas aeruginosa; M. morganii = Morganella morganii; ESBLP = extended-spectrum beta-lactamase-producing. *Polymicrobial organisms.*

Discussion

Developing SSI is a traumatic experience.[10] Smyth *et al.* reported SSI to be the third most common type of nosocomial infection, accounting for 14–16%.[11] CS surgery has a 5–20 times higher risk of postpartum infection as compared to vaginal deliveries, mainly with regards to wound infections, endometritis, pelvic peritonitis or pelvic abscesses.[10] Wound infections are still regarded as the most common nosocomial infections in patients undergoing surgery. The most common pathogens were *S. aureus*, *Pseudomonas aeruginosa* and *E. coli*,[12] as was also observed in the current study. *Staphylococcus* is the most common cause of nosocomial infections and is often the cause of postsurgical wound infections; the Gram-positive *cocci* are often found living on the skin and in the nose.

Table 4: Antibiotics prescribed for post-Caesarean wound infections in the study group (N = 211)*

Antibiotic	n	%
Penicillin, amoxycillin, ampicillin and co-amoxiclav	30	14.21
Cloxacillin	20	9.47
Cephalosporin (cephalexin, cefuroxime, ceftriaxone, cefotaxime and ceftazidime)	48	22.74
Aminoglycoside (gentamicin)	52	24.64
Ciprofloxacin	15	7.10
Meropenem	20	9.47
Sulfamethoxazole/trimethoprim	10	4.73
Fusidic acid	16	7.58
Total	**211**	**100**

**Antibiotics were prescribed as per culture sensitivity.*

To avoid any infections from *Staphylococcus* bacteria, it is important to implement regular hand-washing and ensure that wounds are kept covered with clean, dry bandages until they are fully healed. Shittu *et al*. recommended collaboration with a microbiologist and wound-care practitioners, and patient education on personal hygiene to help control wound infections.[12]

Even though the annual number of CS procedures at Nizwa Hospital has consistently risen, from 240 in 2001 to 1,099 in 2012, the rate of wound infection has remained more or less constant. This may be due to high compliance among the infection control team and medical personnel in the hospital regarding its infection control rules and policies. These include hand-washing, the use of alcohol rubs, avoiding cross-infection by restricting visitors and routine education among health workers regarding infection control measures. The rate of CS wound infections was 2.66% in the current study. Rates of 2.8% were reported by Mah *et al*.[13] and Mathew *et al*.,[14] respectively, and these are comparable to similarly low rates of 2.8% and 2–5% in the USA and certain European countries.[15] Higher rates were noted in other studies, at 9.3%, 9.1% and 9.6% respectively.[16–18] The rate of SSI has been reported to be from 5.7–9.0%[10] and many other studies in various centres reported infection rates ranging from 6.09–38.7%.[1,3,19,20]

Satyanarayan *et al*. reported rates of wound infections as high as 25.2% in emergency CS compared to 7.6% in elective cases.[21] In the current study, 119 (1.50%) suffered wound infections after emergency surgeries compared to 92 (1.16%) in elective cases. The probable reason for this difference may be that less time was available for preoperative preparation in the emergency surgeries. In the current study, a difficult case was reported where the SSI was so severe that it had progressed to necrotising fasciitis. A similar case of wound infection progressing to necrotising fasciitis was reported by Mathew *et al*., which was successfully treated with wound debridement and antibiotics.[14]

An independent risk factor for SSI in the current study was the development of subcutaneous wound haematomas in 15 (7.10%) patients. This suggests lapses in complete haemostasis during the wound closure as a haematoma may provide a medium for bacterial growth. The meticulous closure of potential spaces and good haemostatic techniques would reduce the frequency of haematomas leading to wound infections. Postoperative wound haematoma was the strongest independent risk factor for SSI in a study conducted at a 1,250-bed tertiary care hospital in the USA, where SSI were identified in 5.0% of women undergoing low transverse CS.[20]

Obesity is a major and rapidly growing health problem. The incidence of infections in patients who are obese with a BMI of 30 or more is higher than that of the general population. This is due to the poor penetration of antibiotics into the skin because of the avascularity of adipose tissue. Moreover, obesity places greater mechanical stress on the wound and thus delays healing.[22]

Wloch *et al*. observed that being overweight with a BMI >35 was a major risk factor for infection compared with cases who had a BMI 18.5–25 (OR 3.7, 95% confidence interval [CI] 2.6–5.2).[18] This was also observed in the current study as the rate of wound infections was 18 (8.53%) in women with BMI >35 as compared to 7 (3.18%) with normal body weight (OR 2.83, 95% CI: 1.16–6.94).

Vertical incisions, which have to be used for overweight or obese patients, are more likely to lead to complications than the typical transverse incisions.[23] Women should be encouraged to eat healthily, have a well-balanced diet and take adequate exercise to avoid the risks of SSI associated with obesity.

The incidence of infections in patients with gestational diabetes, either controlled by diet or insulin, was significantly higher (32, 15.16%) than among the non-diabetic patients (12, 5.45%). In other studies, the incidence of wound infections was noted to be six times higher in diabetic patients.[1,24] Uncontrolled blood glucose levels increase the infection rate and impairs wound healing as it enables the leukocytes to control the harmful proliferation of bacteria.

Prolonged labour, after a full trial of vaginal delivery, was observed in 20 (9.47%) cases of wound infections in the current study and similar findings were reported by Ezechi *et al*.[16] Frequent vaginal examinations may be a contributory factor for the increased infection rate in such cases. Most infections in the female genital area or the gastrointestinal tract can contaminate the normally sterile amniotic fluid. An associated risk factor, PROM, increases the risk of chorioamnionitis as the protective effect of the intact fetal membranes is lost. The culture reports in such cases showed polymicrobial growth of both Gram-positive and Gram-negative organisms. Only three (1.42%) cultures showed extended-spectrum beta-lactamase-producing *E. coli* resistant to quinolones and aminoglycosides. Such infections were controlled with carbapenems (meropenem and imipenem). The length of time between the rupture of the membranes and surgical intervention influences the CS wound infection rate as once the membranes have ruptured, the amniotic fluid is no longer sterile and may act as a transport medium, allowing bacteria to come into contact with any uterine and/or skin incisions.[9]

A total of 11 (5.21%) cases with wound infections underwent surgery in other health institutions but

were admitted to Nizwa Hospital for wound care as they belonged to Al Dakhiliyah Governorate and preferred the more convenient location of Nizwa Hospital. These cases were initially screened for MRSA and *Acinetobacter* and were treated accordingly. The majority of the cultures in this study yielded growth of *S. aureus* (31.27%); similar results (71.4%) were documented in Nisa *et al.*'s study.[25]

Departmental policy at Nizwa Hospital strongly advocates using prophylactic antibiotics, for example a second-generation cephalosporin (such as cefuroxime 750–1500 mg), at cord clamping. However, recent evidence suggests that pre-incisional antibiotics reduce maternal morbidity with no disadvantage to the neonate.[8,26] In a number of cases, the infection was polybacterial and warranted the use of combination drugs, mostly ceftriaxone with metronidazole and sometimes an addition of aminoglycoside. Even though quinolones, like ciprofloxacin, were sensitive in 15 (7.10%) cases and showed low resistance, they are avoided in breastfeeding women in Nizwa Hospital. Gentamicin was observed to be highly effective against most of the organisms, with the least drug resistance. Resistant Gram-negative bacteria like *Enterobacter*, *E. coli* and *Klebsiella* were treated with third- and fourth-generation drugs such as cephalosporin, imipenem and meropenem. However, consistent efforts were made to use narrow-spectrum drugs so as to avoid the emergence of drug-resistant strains of bacteria. Cultures of the bacteria were found to be highly resistant to penicillin groups like the ampicillins and amoxicillins in comparison to the sulphonamide group, which was found to have the least resistance. However, this drug was minimally used in this centre due to the risk of undiagnosed cases of glucose-6-phosphate dehydrogenase deficiency which has a high incidence in the Middle East. Riyami *et al.*, in a community-based survey on genetic disorders, found that the prevalence of glucose-6-phosphate dehydrogenase (G6PD) enzyme deficiency was highest (29%) in the Al Dakhiliyah region as compared to other regions of Oman.[27]

CS wound infection increases maternal morbidity and prolongs hospital stays. In Nizwa Hospital, women undergoing CS are routinely discharged on the third postoperative day. However, women suffering SSI stayed in the hospital for an average of 5–8 days. Most of the women developing wound infections following discharge returned 6–10 days later, with complaints of fever, pain, and wound discharge and redness.

The frequency of CS wound infections can be prevented by educational programmes designed to raise public and clinical awareness. Modifiable risk factors like BMI and associated comorbid medical problems, such as diabetes and hypertension, should be closely monitored and controlled in the pre-pregnancy period. Some of the cases with wound infections in the current study were noted to have poor personal hygiene. Standards of personal hygiene, such as bathing every day, are culture-dependent and may also differ according to the individual patient. Women opting for a CS for non-medical reasons should be informed about the risks of SSI as a complication.[2,6]

Measures should be taken in the pre-, intra- and postoperative phases to reduce the risk of infection. In the preoperative phase, certain measures can be beneficial—for example, bathing on the day of the surgery, avoiding the unnecessary shaving of hair, the use of electric clippers, the proper sterilisation of instruments, antibiotic prophylaxis and patient-specific theatre-wear. Additionally, hand-washing, the antiseptic preparation of the surgical site and the use of appropriate staff theatre-wear should be encouraged. Intraoperative infection prevention can be aided by one of the latest practices worldwide which is the use of monofilament sutures. The use of subcuticular sutures buried in the wound is also very unlikely to cause infection.[9] Gregson suggested the use of a Hydrofiber® and hydrocolloid combination dressing (Conva Tec Inc., New Jersey, USA) for control of wound infection.[10] Nevertheless, despite all of these precautions, surgical wound infections may occur in the operating theatre when the tissues are exposed. Postoperative wound infection can be greatly reduced and controlled by rigorous surgical techniques. Furthermore, covering surgical incisions with an interactive dressing able to absorb exudates, placed so as to ease pain and to ensure that they remain in place for a minimum of 48 hours after the operation, is another practice to avoid wound infections.[6]

A satisfactory surveillance system is essential in all hospitals to reduce the rate of sepsis, with reliable feedback to clinicians.[28] In this context, the Infection Control Unit of Nizwa Hospital is currently adopting measures to establish this system. Until now, no wound surveillance office has been established to gather information and tabulate wound infection rates according to surgical specialty. A surgical wound infection task force is recommended to enforce measures and expedite the control of wound infections in this healthcare institution.

There were several limitations to this study. This retrospective study covered a long time period and the accuracy of information regarding the risk factors is limited by several cases with incomplete data. However, it is possible to confirm that all cases of PCS wound infections post-discharge were recorded, as this hospital was the only secondary care institution for such cases in the region.

Conclusion

Even though the rate of CS procedures consistently rose in the study period, the rate of wound infections remained consistent. The rate of CS wound infections was 2.66% between 2001 and 2012. The most common pathogens observed were *S. aureus*, *P. aeruginosa* and *E. coli*, which is in agreement with the results of other studies. The most sensitive antibiotics were aminoglycoside and cephalosporin. Obesity, diabetes, prolonged labour with PROM and wound haematoma were the main contributory risk factors responsible for PCS wound infections.

The need to reduce SSI is currently receiving considerable attention and requires more research. Reducing the rate of SSI will help to reduce the unnecessary morbidity and associated socioeconomic consequences for the patient and her family. Recommendations include addressing modifiable risks factors in the preconception period, ensuring a sterile environment, aseptic surgeries, meticulous haemostatic techniques and the use of antimicrobial prophylaxis to reduce the incidence of infection. Additionally, an organised system of wound surveillance and reporting may help to reduce the wound infection rate to an attainable minimum.

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