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REVIEW

Postcesarean wound infection: prevalence, impact, prevention, and management challenges

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Abstract: Surgical site infection (SSI) is one of the most common complications following cesarean section, and has an incidence of 3%–15%. It places physical and emotional burdens on the mother herself and a significant financial burden on the health care system. Moreover, SSI is associated with a maternal mortality rate of up to 3%. With the global increase in cesarean section rate, it is expected that the occurrence of SSI will increase in parallel, hence its clinical significance. Given its substantial implications, recognizing the consequences and developing strategies to diagnose, prevent, and treat SSI are essential for reducing postcesarean morbidity and mortality. Optimization of maternal comorbidities, appropriate antibiotic prophylaxis, and evidence-based surgical techniques are some of the practices proven to be effective in reducing the incidence of SSI. In this review, we describe the biological mechanism of SSI and risk factors for its occurrence and summarize recent key clinical trials investigating preoperative, intraoperative, and postoperative practices to reduce SSI incidence. It is prudent that the surgical team who perform cesarean sections be familiar with these practices and apply them as needed to minimize maternal morbidity and mortality related to SSI.

Keywords: cesarean section, management, surgical site infection

Introduction

Cesarean delivery is a major obstetrical surgical procedure aiming to save the lives of mothers and fetuses.[1] The incidence of cesarean deliveries, both repeat and primary, has risen dramatically over the last few decades, with an estimated global number of 22.9 million cesarean deliveries in 2012.[2,3] As a surgical procedure, cesarean delivery may be accompanied by a number of complications, surgical site infection (SSI) being one of them. The rate of SSI ranges from 3% to 15% worldwide.[4–6] The variation in incidence may reflect differences in population characteristics and risk factors, perioperative practices, and the duration from the procedure until ascertainment. The risk for developing SSI has significantly decreased in the last three decades, mainly owing to improvements in hygiene conditions, antibiotic prophylaxis, sterile procedures, and other practices.[7,8] Despite this decrease, the occurrence of SSI is expected to increase given the continuous rise in the incidence of cesarean deliveries. Postcesarean SSI may increase maternal morbidity and mortality.[9,10] In addition, SSI can be frustrating for the mother trying to recover from the procedure and at the same time take care of the newborn. It may prolong maternal hospitalization, increase health care costs, and lead to other socioeconomic implications.[9]

Methods

An attempt was made to identify all relevant articles that reported the prevalence, impact, prevention, and management of postcesarean wound infection. The following

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electronic databases were searched from inception through June 2016: MEDLINE, PubMed, Ovid, and the Cochrane Library. The MeSH headings used included combinations of the terms ["cesarean section" OR "cesarean delivery" OR "cesarean"] AND ["infection" OR "surgical site" OR "antibiotic", OR "skin", OR "wound", OR "endometritis", OR "abscess", OR "fasciitis", OR "bacteria"] in the title or abstract. All reference lists from relevant articles were searched for additional eligible studies. Randomized trials, cohort, case–control, review, and meta-analysis were eligible. Excluded were comments, letters to the editor, personal communications, and case reports. The search was limited to publications in English only. Two authors (SZE and RS) selected articles first through focused review of abstracts. Eligible studies underwent full-text review. Disagreements between authors over the inclusion and exclusion of studies were resolved by consensus through discussion between the authors.

Definition and microbiology

The Centers for Disease Control and Prevention defines SSI as an infection occurring within 30 days from the operative procedure in the part of the body where the surgery took place.[11] It divides SSIs into incisional SSI and organ/space SSI. Incisional SSI is further divided into superficial, involving the skin and subcutaneous tissue, and deep SSI, involving fascial and muscle layers.[11]

Staphylococcus aureus is the most common organism isolated in SSI, accounting for 15%–20% of cases. Gram-negative bacilli, coagulase negative staphylococci, *Enterococcus* species, and *Escherichia coli* are other organisms commonly isolated from SSIs.[12] SSI in relation to cesarean delivery has a distinctive microbial source of pathogens composed of both skin and vaginal origin.[13] Accordingly, it is usually a polymicrobial infection consisting of both aerobic bacteria and anaerobic organisms.[14–16] Knowledge of the pathogens and risk factors associated with SSI is essential for developing targeted prevention strategies to reduce the risk and treat the infection.

Risk factors

Several risk factors for developing postcesarean section SSI are noted in the literature. Identification of these factors is vital for creating targeted practices for reducing SSI rate. Risk factors can be divided into three categories: 1) host-related factors, 2) pregnancy and intrapartum-related factors, and 3) procedure-related factors.[17] Host-related risk factors include maternal older or younger age, obesity, residence in rural (compared to urban) area, pregestational diabetes mellitus, previous cesarean delivery, recurrent pregnancy loss, and maternal preoperative condition (American Society of Anesthesiologists score >3). Pregnancy-related factors reported were hypertensive disorder, gestational diabetes mellitus, twin pregnancy, preterm rupture of membranes, greater number of vaginal examinations, prolonged trial of labor prior to surgery, epidural use, use of internal fetal monitoring, and chorioamnionitis. In regard to the procedure itself, SSI was more common among cesarean sections performed in an emergency setting, nonuse of prophylactic antibiotics, and in cases accompanied by uterine rupture, cesarean hysterectomy, need for blood transfusion and in surgeries of longer duration.[5,8,9,18–22] Surgery duration of more than 1 hour had been reported to increase the risk for SSI more than twofold.[21–23]

It should be noted that not all studies evaluated SSI separately, and it is often incorporated in a composite outcome including other infectious and noninfectious morbidities (such as wound breakdown).

Prevention strategies

Many clinical trials explored the implication of various intervention strategies to reduce SSI rate following cesarean section. Recognizing risk factors, particularly those that are modifiable, proper perioperative preparation, and use of distinct surgical techniques have been reported to affect the rate of SSI.[24] The practices used to reduce SSI rate can be divided into three categories according to the time of intervention: preoperative, intraoperative, and postoperative practices.

Preoperative practices

Management of comorbidities

Diabetes mellitus is a well-known comorbidity associated with postoperative wound complications. Poorly controlled diabetes impairs host immune response and delays re-epithelialization of wounds.[25] For diabetic women, perioperative glycemic control may be essential for preventing SSI.[26]

Hair removal

There is no adequate literature to rely on regarding hair removal techniques before cesarean section, and the recommendations are extrapolated from other types of surgery. A Cochrane review published in 2012 suggested that hair removal at the time of surgery was not associated with lower postoperative SSI rates and that it should be done only to facilitate surgery or for applying adhesive dressings.[27]

Shaving the surgical site has been shown to be associated with significantly higher rates of SSI compared to clipping, as a result of microscopic breaks in the skin caused by the razor.[27]

Skin preparation

The skin is a main source of pathogens causing SSI. Preoperative skin preparation with antiseptic agents has been proven to reduce the risk of SSI.[28] There is no consensus regarding what type of skin preparation may be most efficient for the prevention of postcesarean SSI.[29,30] Two large randomized controlled trials (RCTs) assessed this issue. Ngai et al[31] compared chlorhexidine with alcohol, povidone–iodine with alcohol, and the sequential combination of both solutions for preventing SSI postcesarean section. Their study included 1,404 women undergoing nonemergent cesarean section. The three skin preparation groups had similar SSI rates (3.9%–4.6%), leading to the conclusion that no particular method of skin preparation before cesarean section is recommended. However, Tuuli et al[32] evaluated the use of chlorhexidine with alcohol compared to povidone–iodine with alcohol for skin antisepsis in 1,147 women undergoing cesarean section. The use of chlorhexidine–alcohol resulted in a significantly lower risk of overall SSI (4.0%) after cesarean section compared to iodine–alcohol (7.3%) (P=0.02; relative risk [RR]: 0.55; 95% confidence interval [CI]: 0.34–0.9). The incidence of adverse skin reactions was similar in both groups.

Vaginal preparation

This intervention has been evaluated in two systematic reviews. Dahlke et al[33] reported no difference in the incidence of wound infection when adding vaginal preparation to the standard abdominal preparation in cesarean section. In a Cochrane review, vaginal preparation with povidone–iodine solution before cesarean section reduced the risk of postcesarean endometritis from 7.2% to 3.6% (RR: 0.39, 95% CI: 0.16–0.97), particularly in women with ruptured membranes (from 15.4% to 1.4%; RR: 0.13; 95% CI: 0.02–0.66).[34] There was no difference regarding wound infection and postoperative fever.

Antibiotic prophylaxis

A significant component that affects the rate of SSI is the use of antibiotic prophylaxis in cesarean section. Three Cochrane reviews evaluated the role of antibiotic prophylaxis in cesarean section. When comparing antibiotic prophylaxis to no prophylaxis or placebo for preventing infection following cesarean section, the use of prophylactic antibiotics significantly reduced the incidence of wound infection (RR: 0.40, 95% CI: 0.35–0.46), endometritis (RR: 0.38, 95% CI: 0.34–0.42), and maternal serious infectious complications (RR: 0.31, 95% CI: 0.20–0.49).[35] The benefit was noticed in both elective and nonelective cesarean sections. Cephalosporins and penicillins were found to have similar efficacy at cesarean section in preventing immediate postoperative infections, including wound infection.[36] In terms of timing of prophylactic antibiotic administration, women who received antibiotics preoperatively had a lower composite infectious morbidity compared to women who received antibiotics after cord clamping (RR: 0.57, 95% CI: 0.45–0.72).[37] This result was specifically due to reduction in endometritis (RR: 0.54, 95% CI: 0.36–0.79) and wound infection (RR: 0.59, 95% CI: 0.44–0.81). There were no significant differences in adverse neonatal outcomes. When assessing antibiotics doses, single-dose therapy was as efficacious as multiple doses in most studies.[38–40] After a single 1 g intravenous dose of cefazolin, a therapeutic level is maintained for approximately 3–4 hours. A higher dose may be indicated for obese women with body mass index >30 kg/m^2 or weight >100 kg.[41] Several recent studies comparing preoperative 2 g with 3 g cefazolin in morbidly obese gravid women before cesarean section found no difference in the rate of SSI or in the adipose tissue antibiotic concentration between the two regimens.[42–44] One trial did find higher adipose concentrations of cefazolin after administration of 3 g but did not evaluate the effect on SSI occurrence.[45] The American College of Obstetricians and Gynecologists, in its committee opinion, recommends antimicrobial prophylaxis for all cesarean deliveries unless the patient is already receiving an antibiotic regimen with appropriate coverage (eg, for chorioamnionitis). The antibiotics should be administered within 60 minutes before the procedure. A single dose of a targeted antibiotic, such as a first-generation cephalosporin, is the first-line antibiotic of choice, unless significant drug allergies are present. In obese women (body mass index >30 kg/m^2), a higher dose of preoperative antibiotics prophylaxis should be considered. Repeated doses are reserved for particular situations, as in the case of major intraoperative bleeding.[46]

Intraoperative practices

Surgical personnel

Staff education programs and refresher courses in aseptic and scrub techniques have been shown to reduce the incidence of SSI in elective and nonelective cesarean deliveries.[47,48]

Perioperative oxygen supplementation

Several RCTs evaluated the use of high (80%) perioperative oxygen supplementation concentrations versus low (30%) on the incidence of SSI.[49–51] None of the trials found a significant difference, concluding that increasing the concentration of oxygen in women undergoing cesarean deliveries does not decrease the rate of SSI.

Surgical techniques

Skin incision type

A Cochrane review published in 2013 included two studies comparing the Joel-Cohen incision with the Pfannenstiel incision.[52] Overall, there was a 65% reduction in postoperative febrile morbidity (RR: 0.35; 95% CI: 0.14–0.87; *P*=0.023) with the Joel-Cohen incision. Only one study noted the incidence of wound infection separately and found no difference between the two techniques.[53] In regard to muscle cutting, one study compared the Maylard muscle-cutting incision with the Pfannenstiel incision and reported no difference in febrile morbidity (RR: 1.26; 95% CI: 0.08–19.50, *P*=0.87) or wound infection (RR: 1.26; 95% CI: 0.27–5.91; *P*=0.77).[54]

The CORONIS trial,[55] a multicenter, unmasked RCT conducted at 19 institutions, assessed the effect of five elements of the cesarean section technique on maternal and neonatal outcomes. Blunt versus sharp abdominal entry was one of the five elements that were examined. The findings did not show significant differences between the groups regarding febrile morbidity, endometritis, or wound infection.

Expansion of uterine incision

Five studies were included in the Cochrane review that compared blunt versus sharp dissection when performing the uterine incision.[56] There was no significant difference in febrile morbidity following blunt or sharp extension of the uterine incision. The mean blood loss (−55.00 mL; 95% CI: −79.48 to −30.52; *P*=0.00001) and the need for blood transfusion (RR: 0.24; 95% CI: 0.09–0.62; *P*=0.0035) were significantly lower following blunt extension.[56] A meta-analysis evaluating the same interventions found that blunt expansion was associated with fewer unintended extensions and favorable maternal outcomes with no difference in the rate of endometritis compared to sharp dissection.[57] Another meta-analysis that compared cephalad–caudad versus transverse blunt expansion of the low transverse uterine incision during cesarean delivery found that the cephalad–caudad direction was associated with lower risks of postpartum blood loss, unintended extension, uterine vessels injury, and use of additional stitches. The effect on wound infection was not addressed.[58]

Placental removal

Spontaneous placental delivery with gentle cord traction compared to manual removal of the placenta was examined in a Cochrane review in 2010.[59] Manual removal of the placenta was associated with more endometritis (RR: 1.64; 95% CI: 1.42–1.90; *P*<0.00001) and more blood loss (94.42 mL; 95% CI: 17.19–171.64; *P*=0.017). The review did not evaluate the effect of placental delivery on wound infection. One study reported the effect of the two placental delivery techniques on wound infection and found no difference between the two techniques.[60]

Uterine exteriorization

Extra-abdominal compared to intra-abdominal repair of the uterine incision was evaluated in the CORONIS study and in a large meta-analysis.[55,61] Both found no significant differences in complication rates, including endometritis and wound infection, between the two techniques and concluded that both options are acceptable.

Cervical dilatation

Two reviews evaluated the effect of mechanical cervical dilatation during cesarean section on infectious morbidity. Both found that mechanical cervical dilatation did not affect postcesarean infectious morbidity (including wound infection and endometritis).[62,63]

Closure of the uterine incision

Single layer uterine closure versus double layer was examined in two large RCTs and a Cochrane review.[55,56,64] There was no difference in postoperative febrile morbidity, wound infection, and endometritis between the two techniques.

Peritoneal closure

A Cochrane review and two recent large RCTs found no significant difference in the incidence of postoperative endometritis or wound infection in cases with peritoneal closure compared to nonclosure during cesarean section.[55,64,65]

Intra-abdominal saline irrigation

The use of intra-abdominal irrigation before abdominal closure was evaluated in a recent meta-analysis that included three RCTs.[66] Intraoperative saline irrigation was associated with increased intraoperative and postoperative nausea and increased the use of antiemetics without a significant

reduction in infectious morbidity including postpartum endometritis and wound infection.

Subcutaneous tissue closure

According to a Cochrane review, closure of the subcutaneous tissue reduced wound composite morbidity including hematoma, seroma, wound infection, and wound separation (RR: 0.68; 95% CI: 0.52–0.88; P=0.0039). There was no difference in the risk of wound infection alone or other short-term outcomes.[67] In regard to subcutaneous thickness, if depth is <2 cm, there is no difference in wound disruption between closure and nonclosure.[29] In women with subcutaneous thickness >2 cm, closure was associated with a significant decrease in wound complications (RR: 0.66; 95% CI: 0.48–0.91) and is recommended.[29] The use of subcutaneous drainage, regardless of tissue thickness, was not associated with decreased wound morbidity including wound infection.[33,68]

Skin closure

The two most studied methods for skin closure after cesarean section are staples and subcutaneous sutures. A Cochrane review of eight trials concluded that wound complications and cosmetic outcome are similar between the two techniques.[69] In contrast, a large meta-analysis concluded that staples closure is associated with twofold increase in wound infection and separation compared with subcuticular sutures.[70] A multicenter RCT found a significant (57%) decrease in the incidence of wound complications, including wound infection, with suture closure of the skin at cesarean delivery compared with staples (4.9% compared to 10.6%; odds ratio [OR]: 0.43; 95% CI: 0.23–0.78).[71] In particular, wound separation of the skin was significantly decreased from 7.4% to 1.6% in women whose incisions were closed with sutures compared with those closed with staples (OR: 0.2; 95% CI: 0.07–0.51). The study was not powered to assess a difference in wound infection alone. A recent meta-analysis reported a lower incidence of wound separations in those closed with suture compared to staples, with no significant differences in infection rate morbidity.[72]

Wound dressing

There are several types of bandages available for dressing the surgical wound at the end of a surgery. A meta-analysis of 16 trials found no difference in SSI rate between surgical wounds covered with different types of dressings and those left uncovered.[73] Two Cochrane reviews regarding early (<48 hours) versus delayed dressing removal and postoperative bathing reported limited data, but no significant difference in SSI rate was shown.[74,75] Early (6 hours) compared to delayed (24–48 hours) removal of the wound dressing was also recently examined in a RCT. The authors reported comparable wound complications that included infection, disruption, and seroma/hematoma formation. More women were pleased and satisfied with early removal.[76]

Negative pressure wound therapy is the application of suction to healing wounds. The technique is used for the treatment of chronic wounds. Its use on surgical wounds was evaluated in a meta-analysis by Webster et al,[77] which did not find it superior to the traditional dressings in terms of wound complications. There are no available RCTs on its role in cesarean section.

Postoperative assessment

Daily inspection of the cesarean incision is an essential part of the postoperative evaluation. The presence of fever, tenderness, erythema, purulent discharge, or induration should raise a suspicion of infection.[78] Most wound infections do not become clinically apparent until postoperative days 4–7, when most women have already been discharged from the hospital.[78] For that reason, it is essential to instruct these women on signs and symptoms requiring further evaluation since early treatment has an important role in preventing severe consequences.[26]

Management

The management of postcesarean wound infection includes antibiotic treatment, wound exploration, and debridement as soon as indicated.[26]

When there are signs of pelvic infection, empirical broad-spectrum antibiotic regimen should be initiated, including anaerobic coverage. An acceptable regimen includes clindamycin with an aminoglycoside or aztreonam. For the coverage of *Enterococcus*, ampicillin may be added to the regimen.[26,79] Approximately 90% of women will be afebrile within 48–72 hours after initiation of antibiotic treatment. Once the women are afebrile and asymptomatic for 24 hours, parenteral antibiotics may be discontinued. If the infection improves with intravenous antibiotics, there is probably no need to follow the intravenous antibiotics with a course of oral antibiotics.[80]

In cases of wound infection with *S. aureus* (extensive cellulitis), vancomycin should be added to the regimen.[79] Superficial wound infection without purulent discharge can be treated with antibiotics alone. When there is a purulent discharge or concern for deep SSI, the wound must be explored, drained completely, and irrigated. A strict and

cautious inspection of the fascia is indicated. If it is disrupted but not infected (ie, without necrotizing fasciitis), reapproximation is needed. Otherwise, the wound should be irrigated two to three times a day and allowed to heal by secondary intention. Antibiotics should be continued until all signs of infection are resolved.[79]

An uncommon but severe complication of wound infection is necrotizing fasciitis. It is a fast-expanding gangrenous infection involving the skin, subcutaneous tissue, and the fascia.[79] The incidence of necrotizing fasciitis according to Goepfert et al[81] is 1.8 per 1,000 cesarean deliveries, and the mean time to diagnosis was 10 days from the procedure. Necrotizing fasciitis is most likely to occur among immunocompromised patients. The pathogen is usually polymicrobial with *Clostridium* and Group A *Streptococcus*. The presence of crepitation on physical examination or the presence of gas in the subcutaneous tissue on imaging tests can assist in the diagnosis.[26] Necrotizing fasciitis is a life-threatening condition with reported mortality of up to 50%. Early aggressive medical and surgical treatment is the mainstay of management, which includes the combination of broad-spectrum antibiotics with extensive debridement of necrotic tissue.[26]

Conclusion

Cesarean delivery is one of the most frequent surgical interventions performed worldwide and accounts for up to 60% of deliveries in a number of countries.[82,83] It carries risk for various short-term postoperative morbidities including SSI. In addition, infection occurring after delivery may lead to substantial physical and emotional burdens on the mother and to a significant financial burden on the health care system.[84] Likewise, postcesarean infection is a major contributor to maternal death related directly to pregnancy. Review of maternal death in the UK over a period of 3 years (2006–2008) revealed that the incidence of maternal death directly related to pregnancy decreased from 6.24 to 4.67 per 100,000 maternities compared to the period between 2003 and 2005 (P=0.02). In spite of this decline, there has been an increase in maternal death related to genital tract sepsis, mainly from community-acquired Group A streptococcal disease, and sepsis was found to be the leading cause of direct maternal death.[85]

Given its substantial implications, recognizing the consequences and building strategies to prevent and treat SSI are essential for reducing postcesarean maternal morbidity and mortality. To begin with, decreasing or at least controlling the continuous rise in cesarean section rate worldwide is essential in reducing the occurrence of SSI related to the procedure. There are multiple factors that contributed to the increase in cesarean section rate worldwide. However, discussing and presenting recent evidence regarding this essential issue is beyond the scope of this review. In addition, recognizing risk factors, particularly modifiable ones that may be related to the woman, pregnancy, or to the technique itself and implementing strategies to prevent, diagnose, and treat infection in time are all vital steps for reducing the occurrence of SSI and its consequences. Medical staff responsible for the procedure should be familiar with aspects of the procedure that have been evaluated in good clinical trials to minimize maternal and perinatal morbidity and mortality.

Disclosure

The authors report no conflicts of interest in this work.

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