Chapter 4

The Surgical Technique of Caesarean Section: What is Evidence Based?

Jan-Simon Lanowski and
Constantin S. von Kaisenberg

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/intechopen.78040

Abstract

Caesarean section is the most frequent obstetric operation which is associated with increased maternal morbidity and mortality. Although these risks are low, affected women may suffer from severe consequences and this may affect subsequent pregnancies and deliveries. A variety of surgical approaches have been described, however, on low evidence level. The objective of this chapter is therefore to systematically search the literature and analyse the available evidence including preoperative workup, prophylactic antibiotics, skin disinfection, preoperative bladder catheterization as well as details of the individual steps of the actual operation itself such as skin incision types, preparation of soft tissue and womb, removal of the placenta, cervical dilatation and stitching of the womb, peritoneum, rectus muscle, fascia, subcutaneous fat, and skin. We systematically searched for meta-analysis, systematic reviews, and big studies and evaluated the evidence for each individual step.

Keywords: techniques of caesarean section, level of evidence, meta-analysis, systematic review

1. Various approaches of caesarean section

A caesarean section is a common surgical procedure indicated when complications arise during pregnancy or labour such as suspected foetal distress, breech presentation, failure to progress in labour in macrosomia or in some cases of previous caesarean section. Although maternal and foetal mortality and morbidity have become low, it is associated with substantial short- and long-term maternal and neonatal risks such as bleeding, thrombosis and

embolism, infection and sepsis, and injury to the bladder and bowel. Caesarean section also has the potential for major complications in subsequent pregnancies, in particular uterine scar rupture, placenta praevia totalis, placenta percreta, and placental abruption [1, 2]. But most importantly and of major interest are increased risks for the baby such as asthma up to the age of 12 years and obesity up to the age of 5 years. Also the risks for miscarriage and stillbirth are increased, but not perinatal mortality [2].

The frequency of caesarean sections has increased dramatically worldwide within the last two to three decades, especially in middle- and high-income countries [3]. The reasons are multifactorial and factors such as fear of pain, loss of the preservation of the love channel, the misconception that CS is safer for the baby, convenience for both health professionals and the mother and family, increasing fear of medical litigation, and reduced tolerance of complications or adverse outcomes other than the perfect baby [4]. Improvements in surgical techniques, availability of blood products, anaesthesia, and infection control have reduced the threshold to indicate caesarean section [5].

Recent rates of caesarean sections have been reported with 24.5% in Western Europe, 32% in North America, and 41% in South America [1, 6].

Although one of the most commonly practiced operation a consensus on the most appropriate technique has not yet been reached, mostly because well-designed studies and solid evidence have been sparse.

There are different techniques described such as the classic Pfannenstiel-Kerr technique, the Joel-Cohen method, and the Misgav Ladach technique [7].

There are many ways to perform a caesarean section. The **Pfannenstiel-Kerr** technique consists of the Pfannenstiel incision (**Figures 1–3**), which is a transverse skin incision, two fingers above the symphysis pubis, which is extended in the direction of the anterior superior iliac spine (ASIS), and ends 2–3 cm medial to ASIS on both sides [8]. The subcutaneous layer is opened via sharp dissection followed by a sharp extension of the fascia, a sharp superficial uterine incision, and then blunt entry. The placenta is removed manually, and the uterine closure is made by an interrupted single layer closure. The peritoneum is closed, and the fascia is interruptedly closed, followed by omittance of suturing of the subcutaneous layer and continuous suture of the skin.

In the **Joel-Cohen** technique, the skin incision is placed 3 cm above the original Pfannenstiel incision, the subcutaneous tissue is incised only in the three most medial centimetres, and the lateral tissue is separated manually, before the fascia is divided bluntly with both index fingers inserted in the deep fascial space created by the knife. Then, the peritoneum is opened bluntly with fingers, the uterine cavity is incised, and the incision is extended bluntly laterally by two fingers [9]. The placenta is delivered spontaneously, after delivery of the baby [10]. The uterine closure is made by a single interrupted layer, the peritoneal closure is omitted, and the fascial closure is also interrupted. The subcutaneous suture is omitted, and the skin is sutured continuously (**Figures 4** and **5**). The Joel-Cohen technique is claimed to be faster to

http://dx.doi.org/10.5772/intechopen.78040

Figure 1. This is a 37 year old IG0P at 38 weeks and 5 days.

Figure 2. Indicates the skin incision.

Figure 3. The skin is fully incised.

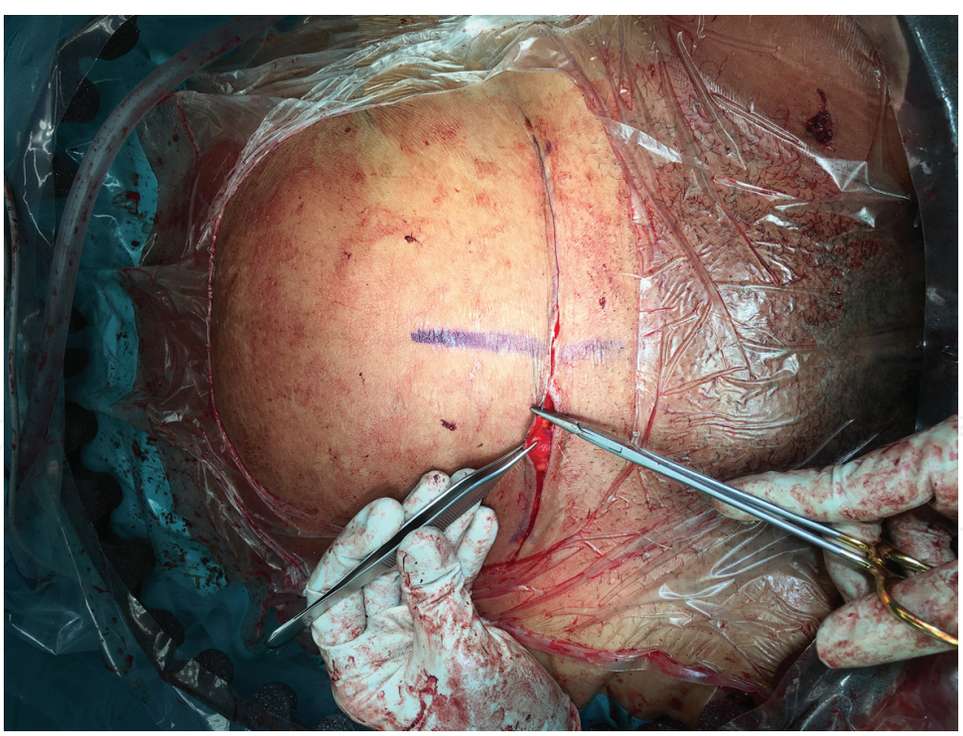

Figure 4. The skin is being closed following the cesarean section.

perform, causes less blood loss, less postoperative pain, shorter hospital stay, less postoperative infection, is more economic, and saves more staff time, and utilises less anaesthesia in comparison with the Pfannenstiel-Kerr technique [11].

http://dx.doi.org/10.5772/intechopen.78040

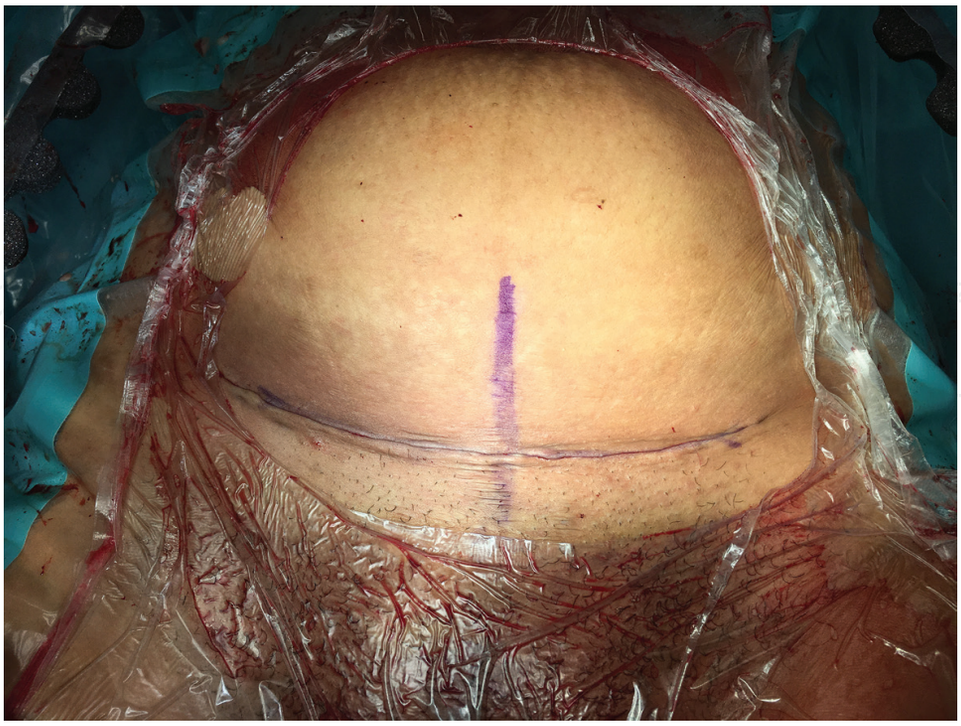

Figure 5. View cesarean section completed.

The **Misgav Ladach** technique for caesarean section was first described by Michael Stark, based on the Joel-Cohen incision. It was initially introduced at Misgav Ladach hospital in Israel [12]. The procedure includes a transverse skin incision 5 cm above the symphysis pubis and blunt dissection of all abdominal walls after sharp superficial incision of the fascia (**Figures 6** and **7**) and uterus (**Figure 8**). The placenta is removed manually after delivery of the baby. One running layer suturing the uterus (**Figures 9** and **10**) [13] and non-closure of the peritoneum were also considered acceptable by many during 1990s [14]. The fascia is closed continuously, the subcutaneous layer is not sutured, and the skin is closed with a mattress suture. A modification of the Misgav Ladach technique was suggested by Stark in 1995 [15].

The Misgav Ladach technique is claimed to have several advantages compared with the Pfannenstiel-Kerr technique. Major differences are digital manual manipulation instead of using sharp instruments which is associated with the least possible trauma to the tissues, less blood loss, faster recovery, shorter anaesthetic time, and using less suture material [16]. A reduced level of antibiotic and narcotic use, faster return of normal bowel function, shorter maternal hospital stay and less postoperative adhesion formation as well as lower incidence of fever, and urinary tract infection has been suggested for that technique. The Misgav Ladach technique is suitable for both elective and emergency caesarean section [17].

The modified Misgav Ladach technique, other than the original Misgav Ladach technique, uses a Pfannenstiel skin incision, a spontaneous delivery of the placenta, a peritoneal closure, and a continuous closure of the skin [7].

Figure 6. Dissection of the fascia and blunt dilatation of abdominal rectus muscles.

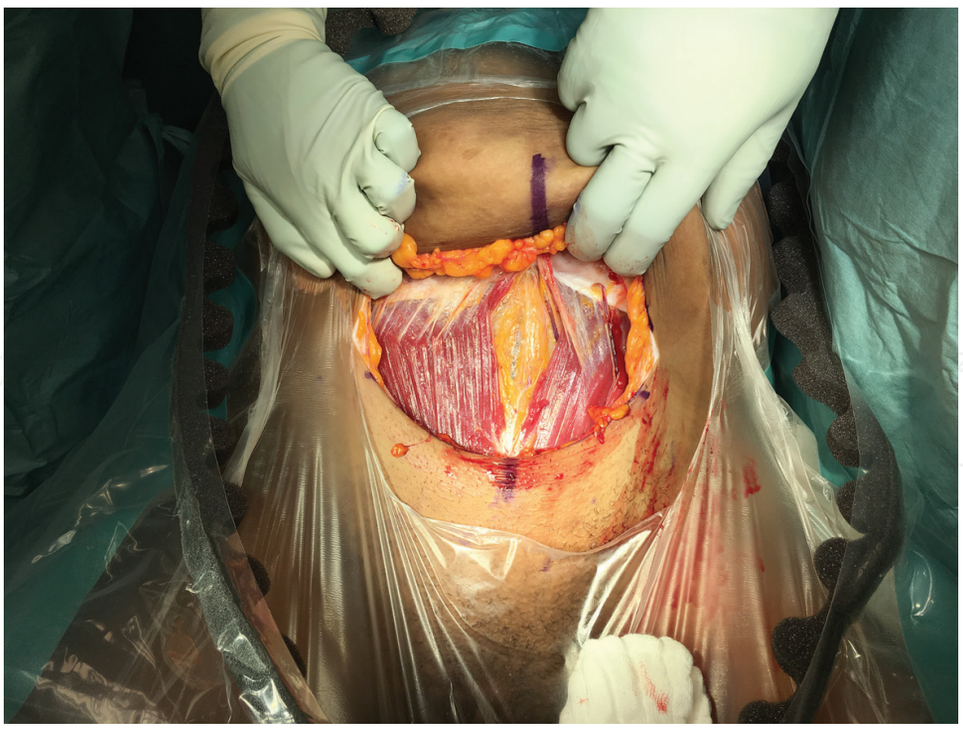

Figure 7. Further digital preparation cranially.

http://dx.doi.org/10.5772/intechopen.78040

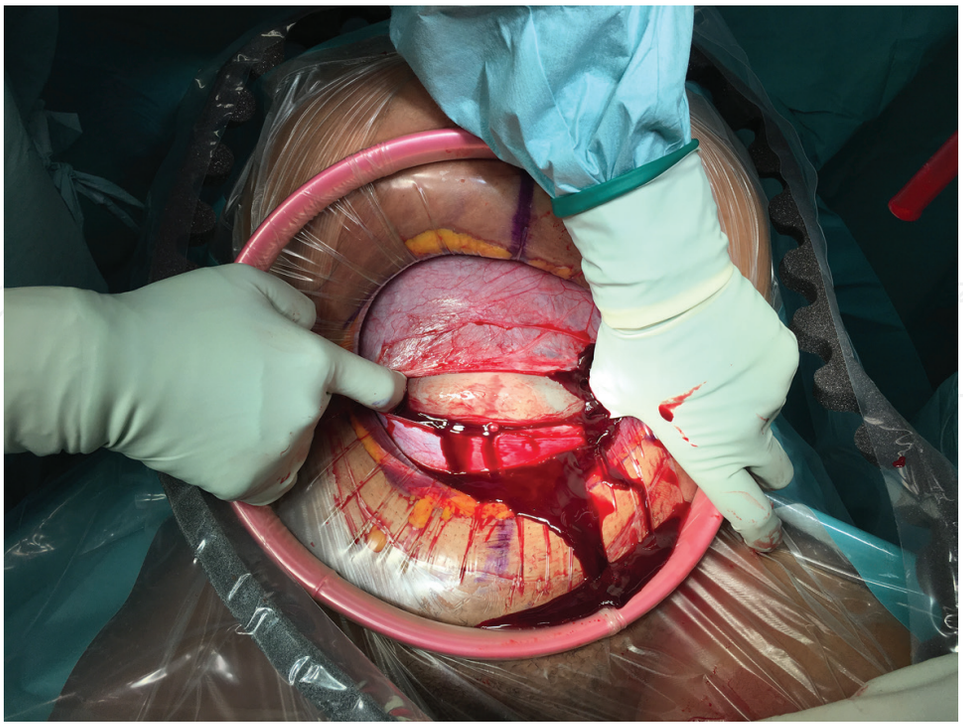

Figure 8. Dilatation of myometrium after uterine incision.

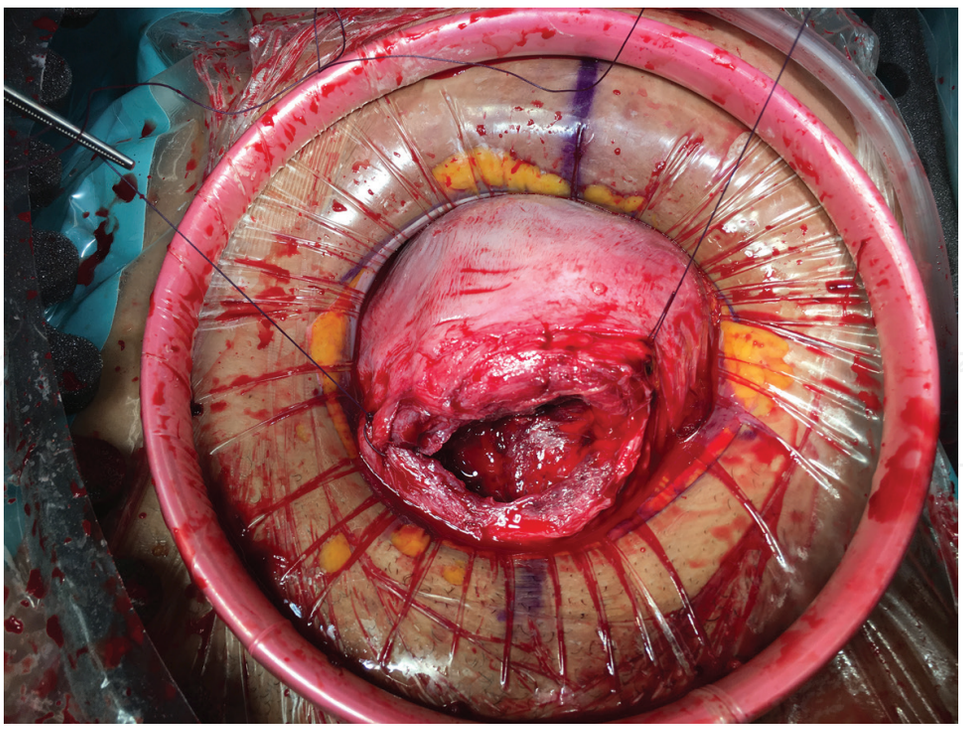

Figure 9. The baby has been removed, the edges are secured, continuous uterine suture is to commence.

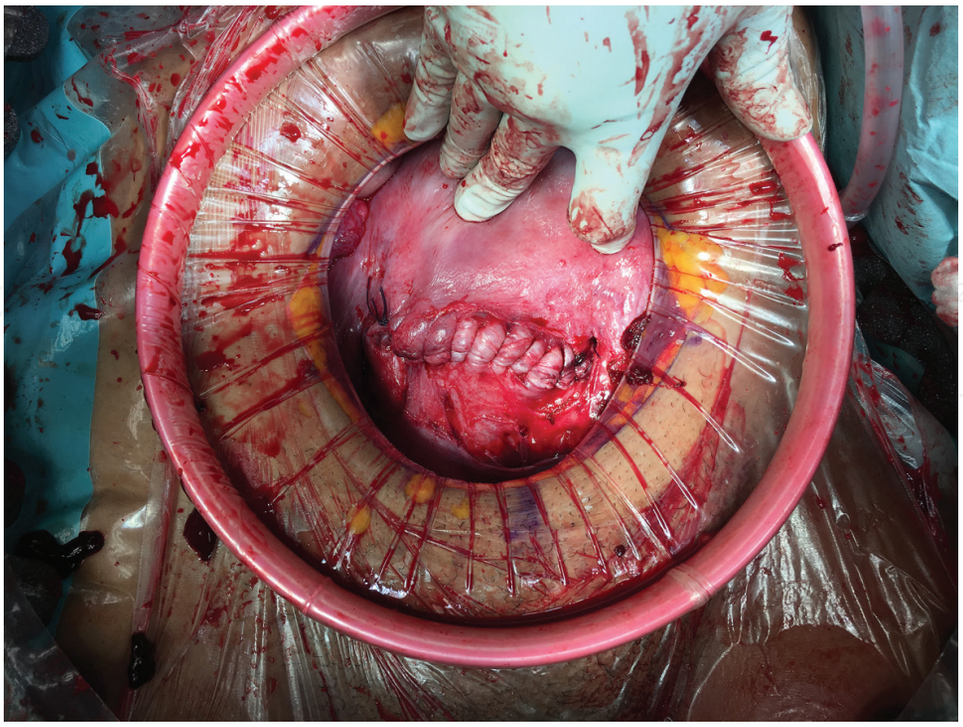

Figure 10. Completion of uterine suture.

It is important that surgeons use techniques which have been shown to be associated with low rates of maternal morbidity and mortality. Therefore, the objective of this chapter is to systematically search the literature and analyse the available evidence for robustness including preoperative workup, prophylactic antibiotics, skin disinfection, preoperative bladder catheterization as well as details of the individual steps of the actual operation itself such as skin incision types, preparation of soft tissue and womb, removal of the placenta, cervical dilatation and stitching of the womb, peritoneum, rectus muscle, fascia, subcutaneous fat, and skin.

2. Data collection

We did a systematic literature review of PubMed and the Cochrane Database in English. Search terms used were techniques of caesarean section, randomised controlled trials, meta-analysis, systematic reviews, Cochrane systematic review, prophylactic antibiotics, skin disinfection, preoperative bladder catheterization, skin incision types, dissection of fascia off the rectus muscles, bladder flap, uterine incision, removal of the placenta, cervical dilatation, closure of the uterine incision, closure of the peritoneum, subcutaneous closure, prophylactic drainage, and skin closure.

Before the search, we defined inclusion criteria and exclusion criteria:

Inclusion criteria: randomised controlled trials, cohort, case-control, systematic review, meta-analysis, and the above search terms.

Exclusion criteria: comments, letters to the editor, personal communications, and case reports.

The author selected the articles first through focused review of abstracts. Eligible studies underwent full text review.

We identified a total of 4593 studies.

We excluded 4532 studies for not meeting either the inclusion criteria, for meeting the exclusion criteria or for not answering the question.

The resulting number of studies was analysed (abstract: 61, whole paper were downloaded: 60).

The references of the most important studies were again checked for eligibility as part of the search strategy.

Data from the randomised controlled trials and Cochrane systematic reviews were extracted, and each step of the operation was discussed using the available evidence.

Potential outcomes were: the technique/procedure which should be used, should not be used, no/low evidence available to answer the question.

Thus, the result of this chapter is a summary of the conclusions of each one of the individual steps to perform a caesarean section.

From the abstracts retrieved by our search, we identified 49 studies and 12 Cochrane systematic reviews. All manuscripts were retrieved in electronic pdf format and analysed in detail.

3. Preoperative preparation

3.1. Prophylactic antibiotics

Wound infection and postpartum endometritis following caesarean section are a frequent problem associated with maternal morbidity and mortality. Caesarean section is the most important risk factor for puerperal infection, and the incidence varies worldwide between 2.5 and 20.5% [18]. The infection is mostly polymicrobial involving a spectrum of Gram-positive and Gram-negative bacteria, anaerobes, *Gardnerella vaginalis*, and genital mycoplasmas [19].

Antibiotic prophylaxis is generally recommended for preventing infection after caesarean section. The administration of antibiotic prophylaxis should be effective, safe, and convenient. The route of administrating antibiotic prophylaxis can either be intravenous, orally or by antibiotic irrigation (washing with a saline solution containing antibiotics). Nine studies compared the administration of intravenous antibiotics with antibiotic irrigation and were analysed in a Cochrane systematic review [20]. The differences in the frequency of endometritis and wound infection between intravenous antibiotics and irrigation following caesarean delivery were not significant, but the evidence was of low quality.

Other studies have evaluated different prophylactic antibiotic regimens and compared single dose antibiotics with extended spectrum coverage. Ampicillin/sulbactam [21], triple antibiotic (ampicillin, gentamicin, and metronidazole) [22], and penicillin and cephalothin [23] were compared with standard cephalosporin prophylaxis. There was no improvement shown in giving an extended spectrum coverage compared to a single drug. Thus, a single dose of ampicillin or first generation cephalosporin should be administered as a prophylaxis in women undergoing caesarean delivery. The level of evidence was high.

The timing of antibiotic administration is also discussed in the literature. Some authors claim that antibiotic prophylaxis should be given preoperative, whereas others recommend it after cord clamping. In a Cochrane systematic review, 10 studies were analysed showing that antibiotics given to women before caesarean delivery nearly halved the risks of combined infections (43%), wound infection (41%), and endometritis (46%), compared to giving the antibiotics after clamping the umbilical cord [24]. Urinary and lung infections, febrile illness, and pelvic abscess did not differ in the two groups, nor did adverse effects in newborns. A meta-analysis of 5 RCT's showed that preoperative administration should be given 15–60 min prior to skin incision to reduce the risk of postpartum infection [25].

Antibiotic prophylaxis should therefore be given prior to the operation. The evidence was of high quality.

3.2. Skin disinfection

Women who give birth by caesarean section are exposed to surgical site infections. The rate of post caesarean infection has been estimated to be 10 times greater than that after vaginal birth [26]. The incidence of wound infection following caesarean section ranges from 3 to 15%. Risk factors for a wound infection are obesity, diabetes, immunosuppressive disorders (HIV infection), and chorioamnionitis during labour, anaemia, or women taking corticosteroids [27]. In order to reduce the risk of postpartum infection, adequate preparation of the skin before the incision is mandatory and is recommended by bodies such as the Royal College of Surgeons of England [28] and the Center for Disease Control and Prevention [29]. An application of an antiseptic is necessary to reduce or remove bacteria. Commonly used antiseptics include chlorhexidine, parachlorometaxylenol, iodine or povidone-iodine, and alcohol. They can be applied as liquids or powders, scrubs or on impregnated drapes. The antiseptic and the type of application given should be broadspectrum and fast acting.

A Cochrane review of skin preparations for clean surgery [30] found that preoperative skin preparation with 0.5% chlorhexidine in methylated spirits was associated with lower rates of surgical site infections following clean surgery, than alcohol-based povidone-iodine, but the evidence of two studies was low. A more recent Cochrane review for skin preparation for preventing infection following caesarean section of six trials found no advantage in either one of the techniques used [31]. Only one trial showed that chlorhexidine gluconate, compared with iodine alone, was associated with lower rates of bacterial growth after caesarean section, but the quality of evidence was very low. More high quality research is necessary to answer the question of the most sufficient preoperative skin preparation.

http://dx.doi.org/10.5772/intechopen.78040

3.3. Preoperative bladder catheterization

Bladder evacuation with an indwelling catheter is a common preoperative procedure prior to CS. Alleged advantages of using catheters include a maintaining bladder drainage that may improve visualisation during surgery and minimise bladder injury. It is also linked with less retention of urine after operation with decreased incidence of postpartum haemorrhage due to uterine atony. But urinary catheters are associated with an increased risk of urinary tract infections, and the prevalence varies from 6 to 80% [32]. Catheter-associated urinary tract infections can lead to such complications as cystitis, pyelonephritis, and septicaemia which are uncomfortable for women and cause prolonged hospital stay, increased cost, and mortality [33].

A Cochrane review for indwelling bladder catheterisation as part of intraoperative and postoperative care for caesarean section included five studies of moderate quality [34]. Interestingly, urinary tract infection as defined by trialists was not different between the catheterised and non-catheterised group. There was also no difference shown in the incidence of postpartum haemorrhage (PPH) due to uterine atony. Given the low incidence of bladder or ureteral injury reported in the literature [35], these trials were underpowered to detect a difference in these outcomes. On the other hand, discomfort due to catheterisation or at first voiding and longer hospitalisation favoured the no catheter group, but there was marked heterogeneity among the included studies. Based on the Cochrane review, there is insufficient evidence to assess the routine use of indwelling urinary catheters for intra- and postoperative care in patients undergoing caesarean delivery [34]. The level of evidence was moderate.

4. Intraoperative techniques

4.1. Skin incision types

Different types of skin incisions of the abdominal wall can be used for caesarean section. Patterns include vertical (midline and paramedian) incisions and transverse incisions (Pfannenstiel-Kerr, Joel-Cohen, Misgav Ladach, and Modified Misgav Ladach). Traditionally, vertical incisions were used for caesarean delivery [36], but the disadvantages of a vertical incision are greater risk of postoperative wound dehiscence and development of incisional hernia as well as cosmetical inconvenience. Nowadays, the lower abdominal transverse incision is adequate for the majority of caesarean operations because of the minimal risk of postoperative disruption, less incisional hernia, and cosmetic approval. Pfannenstiel and Joel-Cohen incision are described above and were analysed in a Cochrane review. Two trials [37–39] including 411 women compared the Joel-Cohen incision with Pfannenstiel incision, whereas all other aspects of surgery in these two trials were identical [40]. In the Cochrane review was shown that postoperative febrile morbidity and postoperative analgesic requirements were less, the operating time, the delivery time, the total dose of analgesia, the estimated blood loss, and the postoperative hospital stay for the mother were reduced in the Joel-Cohen group

compared with the Pfannenstiel group [40]. Altogether, the Joel-Cohen incision is associated with some advantages compared with the Pfannenstiel incision and should be recommended, but is less popular with women for cosmetic reasons.

The level of evidence was moderate.

4.2. Dissection of fascia off the rectus muscles

This question has been evaluated in a randomised controlled trial [41]. Non-dissection of the lower rectus fascia (pulling the fascia slowly manually apart) was associated with lower decline of pre- and post-surgical haemoglobin levels and less pain and should be recommended. The level of evidence was low.

4.3. Bladder flap

The bladder flap development (downwards removal of the bladder from the lower uterine segment) versus omission of the bladder flap has been investigated in a randomised controlled trial with 258 women. Omission of the bladder flap at caesarean delivery (primary and repeat) did not increase intraoperative or postoperative complications such as blood loss, postoperative micro haematuria, postoperative pain, hospital days, endometritis, or urinary tract infection but shortened incision to delivery time [42].

In another trial with 620 patients, it was shown that the visceral peritoneal closure of the bladder flap increased postpartum urinary frequency [43]. Because of those trials, the routine bladder flap development and closure of the visceral peritoneum of the bladder flap cannot be recommended, but trials have been underpowered to assess morbidity such as bladder injury and adhesion formation. The evidence was of moderate quality.

4.4. Uterine incision

A Cochrane review specifically assessed surgical techniques involving the uterus at the time of caesarean section and included the type of uterine incision (lower transverse uterine incision versus other types of uterine incision) and methods of performing the uterine incision ('sharp' uterine entry versus 'blunt' uterine entry) [44]. A transverse lower segment uterine incision, which is favoured by many obstetricians because of less vascularisation of the lower uterine segment, a better closure and less incidence of uterine dehiscence or rupture in subsequent pregnancies [45] is compared with other types of uterine incision (low vertical, 'classical', T-shaped or J-shaped incision). The Cochrane review did not identify any randomised controlled trials assessing the type of uterine incision to be used. But the ACOG stressed that uterine rupture is a significant risk in a subsequent pregnancy or labour, with estimates of occurrence being 4–9% for classical (uterine body and midline) caesarean incision, 4–9% for inverted T-shaped incisions, 1–7% for lower uterine segment vertical incisions, and 0.2–1.5% for lower uterine segment transverse incisions [46].

Methods of performing the uterine incision ('sharp' uterine entry versus 'blunt' uterine entry) were compared in five studies including 2141 women, and the Cochrane review pointed out

that there were no statistically significant differences identified for the primary outcome febrile morbidity following blunt or sharp extension of the uterine incision, whereas mean blood loss and the need for blood were significantly lower following blunt extension, with no other significant differences identified in duration of operative procedure and maternal morbidity. No statistically significant difference was seen in the rate of neonatal injury. Therefore, blunt extension should be recommended. The level of evidence is high.

4.5. Removal of the placenta

The mode of placental delivery contributes to morbidity and determines blood loss during caesarean section [47]. Altogether there are two common methods used to deliver the placenta at caesarean section, by spontaneous delivery with mild cord traction and by manual removal. A Cochrane review compared the effects of manual removal of the placenta with cord traction at caesarean section, and 15 studies including 4694 women were analysed [48]. It was pointed out that the manual removal of the placenta was associated with more blood loss, more endometritis, and longer duration of hospital stay compared with cord traction. No significant differences were shown in fetomaternal haemorrhage, blood transfusion, and puerperal fever. Therefore, spontaneous delivery with cord traction should be used, and the level of evidence was high.

4.6. Cervical dilatation

During elective, non-labour caesarean sections cervical dilatation by using finger, sponge forceps or other instruments are performed by some obstetricians after placental removal. On the one hand, it is discussed that an undilated cervix may cause obstruction of blood or lochia drainage, but on the other hand, mechanical cervical dilatation using a finger or instruments during caesarean section may result in contamination and increase the risk of infection or cervical trauma. One randomised controlled trial [49] and one Cochrane review analysing three trials with a total of 735 women [50] found insufficient evidence of mechanical dilatation of the cervix at non-labour caesarean section for reducing postoperative morbidity. This does not justify cervical dilatation at present. Further, randomised controlled trials with adequate methodological quality are needed.

4.7. Closure of the uterine incision

The traditional approach to uterine suture is double layer closed [13], although a variety of techniques has been discussed in the literature. Haemostasis, wound healing, and possibly a reduced risk of uterine rupture in subsequent pregnancies are discussed as potential benefits of a double layer suture, whereas single layer closure may be associated with reduced operating time, reduced tissue disruption, and less suture material being absorbed in the wound.

In a Cochrane systematic review, 19 studies were identified comparing single layer with double layer closure of the uterus [44], and data of 14 of the studies were analysed in a meta-analysis. The systematic review pointed out that there were no statistically significant differences

in febrile morbidity in both groups. They also found that mean blood loss was reduced in the single layer closure, but heterogeneity was high, and this limits the clinical applicability of the result. No statistically significant differences were also found for the risk of blood transfusion or other clinical outcomes.

One study was identified comparing continuous versus interrupted single layer closure for the uterine incision, but no clinical or maternal outcome was assessed using either ultrasound or hysteroscopy [51].

In a separate meta-analysis, uterine exteriorization for hysterotomy repair was compared with intra-abdominal repair, and it was shown that febrile complications and surgical time were similar between both groups, and the decision should be provided by the surgeon's preference [52].

Closure with catgut was compared with polygactin-910 closure in 9544 women, where a significant reduction in the need for blood transfusion and a significant reduction in complications requiring relaparotomy were seen in the catgut closure group [53–58]; however, there was no significant difference in any other clinical outcome.

Altogether, there is limited high quality information available to suggest that one surgical technique of closing the uterine incision is superior to another, in particular regarding the chances of uterine rupture in subsequent vaginal birth following caesarean section (VBAC), and future randomised trials should be adequately powered to detect important differences in clinically relevant outcomes.

4.8. Closure of the peritoneum

Closure of the peritoneum at laparotomy has been a part of standard surgical practice. Possible advantages of closing the peritoneum after caesarean section include restoration of anatomy, reduction of infection, reduction of wound dehiscence, reducing haemorrhage, and a minimisation of adhesions [59], whereas the suturing of the peritoneum may cause peritoneal tissue ischaemia at the edges, which may delay healing and serve as a cause of intraperitoneal adhesions and febrile morbidity.

In a Cochrane systematic review, different types of the closure versus non-closure of the peritoneum during caesarean section were analysed [60].

We looked at the results of 16 studies including 15,480 women, when both parietal peritoneums were left unclosed versus when both peritoneal surfaces were closed. In four trials, no differences were seen in the postoperative adhesion formation, whereas there were a reduction of operating time, a reduction in hospital stay, and less chronic pelvic pain in the peritoneal non-closure group. No differences were seen in the occurrence of infectious morbidity, endometritis, and wound infection. The quality of the trials was variable with some of the outcomes demonstrating significant heterogeneity.

Three studies including 889 women investigated non-closure of visceral peritoneum versus closure of both peritoneal layers. In two trials, adhesion formation was increased in the

visceral peritoneal non-closure group, but it was at high risk of bias, whereas one study showed a reduction in operating time and postoperative hospital days [61].

Two studies with 573 women compared non-closure of parietal peritoneum only with closure of both parietal and visceral peritoneum and stressed that neither study reported on postoperative adhesion formation, but one study showed that there were no significant differences in endometritis, fever, wound infection, or hospital stay, but the operative time was reduced, and a reduction of pain was seen in the non-closure group [62].

One study examined non-closure versus closure of visceral peritoneum when parietal peritoneum is closed and pointed out that there was reduction in urinary symptoms of frequency, urgency, and stress incontinence when the visceral peritoneum is left unsutured [63].

Altogether, there was a reduction in operative time across all the subgroups with the peritoneum left open, and there was no clear evidence on reduced adhesion formation for the peritoneum closure group. At the moment, there is insufficient evidence of advantages to justify the additional time and use of suture material necessary for peritoneal closure.

The Cochrane review stressed that quality of trials was variable, the results were in general consistent between the trials of better and poorer quality, and further studies are needed to further assess all outcomes [60].

4.9. Subcutaneous closure

In a Cochrane review, 7 trials with 2056 women were analysed showing that the risk of haematoma or seroma was reduced with subcutaneous closure compared with non-closure but no difference in the risk of wound infection or other short-term outcomes was found [64]. A meta-analysis evaluating six randomised studies showed that prophylactic drainage was not associated with decreased wound infection, hematoma, or seroma and cannot be recommended [65].

No difference was seen in the risk of wound infection between blunt needles and sharp needles, and no trials were found investigating suture techniques or materials for closure of the rectus sheath or subcutaneous fat. Closure of the subcutaneous fat may reduce wound complications, especially when subcutaneous fat is >2 cm, but further trials are needed which are adequately powered to detect clinically important differences.

4.10. Skin closure

The skin incision can be closed by subcuticular suture immediately below the skin layer, by an interrupted suture, or by staples. In a review of five randomised controlled trials and one prospective study, staple closure was associated with a two-times higher risk of wound infection or separation compared with subcuticular suture closure [66]. In contrast to this data, a Cochrane systematic review of eight studies stressed that wound complications and cosmetic outcomes were similar among both groups [67]. There is currently no conclusive evidence about how the skin should be closed after caesarean section.

5. Summary (suggested strategy/protocol)

- **Prophylactic antibiotics**: yes, single dose, ampicillin or first-generation cephalosporin, 15–60 min prior to skin incision, LoE: high.
- **Skin disinfection**: yes, always, LoE: high; type of antiseptic chlorhexidine gluconate, LoE: low.
- **Preoperative bladder catheterization**: none or early removal, not enough evidence to assess the routine use of indwelling bladder catheters, LoE: moderate.
- **Skin incision types**: Joel-Cohen incision is associated with some advantages compared to Pfannenstiel, but less popular for cosmetic reasons, LoE: moderate.
- **Dissection of fascia off the rectus muscles**: no, median incision and blunt dilatation of the lower rectus fascia, LoE: low.
- **Bladder flap:** no, LoE: moderate.
- **Uterine incision:** transverse lower uterine segment, LoE: moderate; blunt expansion, LoE: high.
- **Removal of the placenta:** yes, spontaneous (with mild cord traction), LoE: high.
- **Cervical dilatation**: no, does not reduce morbidity from infection, LoE: high.
- **Closure of the uterine incision:** single layer, LoE: high; continuous and unlocked, LoE: moderate.
- **Closure of the peritoneum**: no, generally not recommended, individual decision, LoE: moderate.
- **Subcutaneous closure:** yes, if subcutaneous tissue >2 cm, LoE: high.
- **Subcutaneous drain:** no, does not reduce wound morbidity/infection, LoE: high.
- **Skin closure:** staples or subcuticular suture possible, LoE: moderate.

Author details

Jan-Simon Lanowski and Constantin S. von Kaisenberg*

*Address all correspondence to: vonkaisenberg.constantin@mh-hannover.de

Department of Obstetrics, Gynecology and Reproductive Medicine Hannover Medical School, Hannover, Germany

References

[1] Betrán AP, Ye J, Moller AB, Zhang J, Gülmezoglu AM, Torloni MR. The increasing trend in caesarean section rates: Global, regional and national estimates: 1990-2014. PLoS One. 2016;**11**(2):e0148343. DOI: 10.1371/journal.pone.0148343. eCollection 2016

[2] Keag OE, Norman JE, Stock SJ. Long-term risks and benefits associated with caesarean delivery for mother, baby, and subsequent pregnancies: Systematic review and meta-analysis. PLoS Medicine. 2018;**15**(1):e1002494. DOI: 10.1371/journal.pmed.1002494. eCollection 2018 Jan

[3] Lumbiganon P, Laopaiboon M, Gulmezoglu AM, Souza JP, Taneepanichskul S, Ruyan P, et al. Method of delivery and pregnancy outcomes in Asia: the WHO global survey on maternal and perinatal health 2007-08. Lancet. 2010;**375**(9713):490-499. DOI: 10.1016/S0140-6736(09)61870-5. [PubMed]

[4] Hellerstein S, Feldman S, Duan T. China's 50% caesarean delivery rate: Is it too high? BJOG : An International Journal of Obstetrics and Gynaecology. 2015;**122**(2):160-164. DOI: 10.1111/1471-0528.12971. Epub 2014 Aug 20

[5] Vejnović TR, Costa SD, Ignatov A. New technique for caesarean section. Geburtshilfe und Frauenheilkunde. 2012;**72**(9):840-845. DOI: 10.1055/s-0032-1315347

[6] Gibbons L, Belizan JM, Lauer JA, Betra AP, Merialdi M, Althabe F. The global numbers and costs of additionally needed and unnecessary caesarean sections performed per year: Overuse as a barrier to universal coverage. World Health Report. 2010. Background Paper, 30. http://www.who.int/healthsystems/topics/financing/healthreport/30C-section-costs.pdf

[7] Dahlke JD, Mendez-Figueroa H, Rouse DJ, Berghella V, Baxter JK, Chauhan SP. Evidence-based surgery for caesarean delivery: an updated systematic review. American Journal of Obstetrics and Gynecology. 2013;**209**(4):294-306. DOI: 10.1016/j.ajog.2013.02.043. Epub 2013 Mar 1. Review. PMID: 23467047

[8] Larry C, Matsumoto RR. Caesarean Delivery and Surgery in the Pregnant Patient (Operative obstet.). 2nd ed. Vol. 51. New York: McGraw-Hill Companies; 2002. p. 330. Chapter

[9] Abuelghar WM, El-bishry G, Lamiaa H. Emam Caesarean deliveries by Pfannenstiel versus Joel-Cohen incision: A randomised controlled trial. Journal Of The Turkish-German Gynecological Association. 2013;**14**(4):194-200. DOI: 10.5152/jtgga.2013.75725. Published online 2013 Dec 1. PMCID: PMC3935539

[10] Holmgren G. Reply to: Comparative evaluation of the Misgav-Ladach caesarean section with two traditional techniques. The first four years' experience. Acta Obstetricia et Gynecologica Scandinavica. 2001;**80**:91-92. PMID: 11167200

[11] Moreria P, Moreau JC, Faye ME, Ka S, Kane Gueye SM, Faye EO, et al. Comparison of two caesarean techniques: Classic versus Misgave Ladach caesarean. Journal of Gynecology Obstetrics and Human Reproduction (Paris). 2002;**31**:572-576. PMID: 12407329

[12] Moradan S, Mirmohammadkhani M. Comparison of Misgav-Ladach and Pfannenstiel-Kerr techniques for caesarean section: A randomized controlled trial study. Middle East Journal of Rehabilitation and Health. 2016;**3**(4):e38541. Published online 2016 September 26. DOI: 10.17795/mejrh-38541

[13] Enkin MW, Wilkinson C. Single versus two layer suturing for closing the uterine incision at caesarean section. Cochrane Database of Systematic Reviews. 2000;(2):CD000192. Review. Update in: Cochrane Database Syst Rev. 2006;(3):CD000192. PMID: 10796177

[14] Wilkinson CS, Enkin MW. Peritoneal non-closure at caesarean section. Cochrane Database of Systematic Reviews. 2000;(2):CD000163. Review. Update in: Cochrane Database Syst Rev. 2003;(4):CD000163

[15] Stark M, Chavkin Y, Kupfersztain C, Guedj P, Finkel AR. Evaluation of combinations of procedures in caesarean section. International Journal of Gynaecology and Obstetrics. 1995;**48**(3):273-276

[16] Holmgren G, Sjoholm L, Stark M. The Misgav-Ladach method for caesarean section: Method description. Acta Obstetricia et Gynecologica Scandinavica. 1999;**78**(7):615-621. [PubMed: 10422908]

[17] Fatusic Z, Hudic I, Music A. Misgav-Ladach caesarean section: general consideration. Acta Clinica Croatica. 2011;**50**(1):95-99. [PubMed: 22034788]

[18] Conroy K, Koenig AF, Yu YH, Courtney A, Lee HJ, Norwitz ER. Infectious morbidity after caesarean delivery: 10 strategies to reduce risk. Reviews in Obstetrics and Gynecology. 2012;**5**(2):69-77

[19] Maharaj D. Puerperal pyrexia: A review. Part I. Obstetrical & Gynecological Survey. 2007;Jun;**62**(6):393-399

[20] Nabhan AF, Allam NE, Hamed Abdel-Aziz Salama M. Routes of administration of antibiotic prophylaxis for preventing infection after caesarean section. Cochrane Database of Systematic Reviews. 2016;(6):CD011876. DOI: 10.1002/14651858.CD011876.pub2

[21] Ziogos E, Tsiodras S, Matalliotakis I, Giamarellou H, Kanellakopoulou K. Ampicillin/sulbactam versus cefuroxime as antimicrobial prophylaxis for caesarean delivery: A randomized study. BMC Infectious Diseases. 2010;**10**:341

[22] Alekwe LO, Kuti O, Orji EO, Ogunniyi SO. Comparison of ceftriaxone versus triple drug regimen in the prevention of caesarean section infectious morbidities. The Journal of Maternal-Fetal & Neonatal Medicine. 2008;**21**:638-642

[23] Rudge MV, Atallah AN, Peracoli JC, Tristao Ada R, Mendonca Neto M. Randomized controlled trial on prevention of postcaesarean infection using penicillin and cephalothin in Brazil. Acta Obstetricia et Gynecologica Scandinavica. 2006;**85**:945-948

[24] Mackeen AD, Packard RE, Ota E, Berghella V, Baxter JK. Timing of intravenous prophylactic antibiotics for preventing postpartum infectious morbidity in women undergoing caesarean delivery. Cochrane Database of Systematic Reviews. 2014;(12):CD009516. DOI: 10.1002/14651858.CD009516.pub2

[25] Costantine MM, Rahman M, Ghulmiyah L, et al. Timing of perioperative antibiotics for caesarean delivery: A meta-analysis. American Journal of Obstetrics and Gynecology. 2008;**199**:301.e1-301.e6

[26] Henderson E, Love EJ. Incidence of hospital-acquired infections associated with caesarean section. Journal of Hospital Infection. 1995;**29**:245-255

[27] Cunningham FG, Leveno KJ, Bloom SL, Hauth JC, Gilstrap LC III, Wenstrom KD, et al. Puerperal infection. In: Williams Obstetrics. 22nd ed. New York: McGraw-Hill; 2005

[28] Leaper D, Orr K. Step: Inflammation and Infection. Royal College of Surgeons of England, London; 2001

[29] Mangram JA, Horan TC, Pearson ML, Silver LC, Jarvis WR. Guideline for prevention of surgical site infection. Infection Control and Hospital Epidemiology. 1999;**20**:247-278

[30] Edwards P, Lipp A, Holmes A. Preoperative skin antiseptics for preventing surgical wound infections after clean surgery. Cochrane Database of Systematic Reviews. 2013;(3):1-45. DOI: 10.1002/14651858.CD003949.pub3

[31] Hadiati DR, Hakimi M, Nurdiati DS, Ota E. Skin preparation for preventing infection following caesarean section. Cochrane Database of Systematic Reviews. 2014;(9):CD007462. DOI: 10.1002/14651858.CD007462.pub3

[32] Li L, Wen J, Wang L, Li YP, Li Y. Is routine indwelling catheterisation of the bladder for caesarean section necessary? A systematic review. BJOG: An International Journal of Obstetrics & Gynaecology. 2011;**118**(4):400-409

[33] Klevens RM, Edwards JR, Richards CL Jr, Horan TC, Gaynes RP, Pollock DA, et al. Estimating health care associated infections and deaths in U.S. hospitals. Public Health Reports. 2007;**122**(2):160-166

[34] Abdel-Aleem H, Aboelnasr MF, Jayousi TM, Habib FA. Indwelling bladder catheterisation as part of intraoperative and postoperative care for caesarean section. Cochrane Database of Systematic Reviews. 2014;(4):CD010322. DOI: 10.1002/14651858.CD010322.pub2

[35] Rajasekar D, Hall M. Urinary tract injuries during obstetric intervention. British Journal of Obstetrics and Gynaecology. 1997;**104**:731-734

[36] Myerscough PR. Caesarean section: Sterilization: Hysterectomy. In: Munro Kerr's Operative Obstetrics. 10th ed. London: Bailliere Tindall; 1982. pp. 295-319

[37] Franchi M, Ghezzi F, Raio L, Di Naro E, Miglierina M, Agosti M, et al. Joel-Cohen or Pfannenstiel incision at caesarean delivery: Does it make a difference? Acta Obstetricia et Gynecologica Scandinavica. 2002;**81**:1040-1046

[38] Ghezzi F, Franchi F, Raio L, Di Naro E, Balestreri D, Miglierina M, et al. Pfanenstiel or Joel-Cohen incision at caesarean delivery: A randomized clinical trial. American Journal of Obstetrics and Gynecology. 2001;**184**(1):S166

[39] Mathai M, Ambersheth S, George A. Comparison of two transverse abdominal incisions for caesarean delivery. International Journal of Gynecology & Obstetrics. 2002;**78**:47-49

[40] Mathai M, Hofmeyr GJ, Mathai NE. Abdominal surgical incisions for caesarean section. Cochrane Database of Systematic Reviews. 2013;(5):CD004453. DOI: 10.1002/14651858.CD004453.pub3

[41] Kadir RA, Khan A, Wilcock F, Chapman L. Is inferior dissection of the rectus sheath necessary during Pfannenstiel incision for lower segment caesarean section? A randomised controlled trial. European Journal of Obstetrics, Gynecology, and Reproductive Biology. 2006;**128**:262-266

[42] Tuuli MG, Odibo AO, Macones GA. Utility of the bladder flap at caesarean delivery: a randomized controlled trial. Obstetrics and Gynecology. 2012;**120**:709

[43] Shahin AY, Hameed DA. Does visceral peritoneal closure affect post-caesarean urinary symptoms? A randomized clinical trial. International Urogynecology Journal. 2010;**21**:33-41

[44] Dodd JM, Anderson ER, Gates S, Grivell RM. Surgical techniques for uterine incision and uterine closure at the time of caesarean section. Cochrane Database of Systematic Reviews. 2014;(7):CD004732. DOI: 10.1002/14651858.CD004732.pub3

[45] Tahilramaney MP, Boucher M, Eglinton GS, Beall M, Phelan JP. Previous caesarean section and trial of labor. Factors related to uterine dehiscence. Journal of Reproductive Medicine. 1984;**29**(1):17-21

[46] Practice Bulletin ACOG. Vaginal birth after previous caesarean delivery. International Journal of Gynecology & Obstetrics. 1999;**66**:197-204

[47] Kamel A, El-Mazny A, Salah E, Ramadan W, Hussein AM, Hany A. Manual removal versus spontaneous delivery of the placenta at caesarean section in developing countries: a randomized controlled trial and review of literature. The Journal of Maternal-Fetal & Neonatal Medicine. 2017;**30**:1-6. DOI: 10.1080/14767058.2017.1369522. [Epub ahead of print]

[48] Anorlu RI, Maholwana B, Hofmeyr GJ. Methods of delivering the placenta at caesarean section. Cochrane Database of Systematic Reviews. 2008;(3):CD004737. DOI: 10.1002/14651858.CD004737.pub2

[49] Gungorduk K, Yildirim G, Ark C. Is routine cervical dilatation necessary during elective caesarean section? A randomised controlled trial. Australian and New Zealand Journal of Obstetrics and Gynaecology. 2009;**49**:263-267

[50] Liabsuetrakul T, Peeyananjarassri K. Mechanical dilatation of the cervix at non-labour caesarean section for reducing postoperativemorbidity. Cochrane Database of Systematic Reviews. 2011;(11):CD008019. DOI: 10.1002/14651858.CD008019.pub2

[51] Ceci O, Cantatore C, Scioscia M, Nardelli C, Ravi M, Vimercati A, et al. Ultrasonographic and hysteroscopic outcomes of uterine scar healing after caesarean section: Comparison of two types of single-layer suture. Journal of Obstetrics and Gynaecology Research. 2012;**38**(11):1302-1307

[52] Walsh CA, Walsh SR. Extraabdominal vs intraabdominal uterine repair at caesarean delivery: A metaanalysis. American Journal of Obstetrics and Gynecology. 2009;**200**:625.e1-625.e8

[53] Brocklehurst P, for the CORONIS Trial Collaborative Group. The CORONIS Trial: International study of caesarean section surgical techniques: a randomised fractional factorial randomised trial. BJOG: An International Journal of Obstetrics & Gynaecology. 2013;**120**(Suppl 1):3

[54] CORONIS Collaborative Group. Caesarean section surgical techniques (CORONIS): A fractional, factorial, unmasked, randomised controlled trial. Lancet. 2013;**382**:234-248

[55] Glavind J, Uldbjerg N. Caesarean section: In good surgical skills we trust. Lancet. 2013; **382**:188-189

[56] Juszczak E, Farrell B. The CORONIS Trial: International study of caesarean section surgical techniques. Trials. 2011;**112**(Suppl 1):A103

[57] National Perinatal Epidemiology Unit. Prevention of Maternal Morbidity after Caesarean Section in Developing Countries: A Factorial RCT of Surgical Methods. Available from: http://www.npeu.ox.ac.uk/coronis/ [Accessed: 2008]

[58] The CORONIS Trial Collaborative Group. The CORONIS trial. International study of caesarean section surgical techniques: a randomised fractional, factorial trial. BMC Pregnancy and Childbirth. 2007;**7**:24

[59] Bamigboye AA, Buchman E, Hofmeyr GJ. Closure of peritoneum at laparotomy: a survey of gynecological practice. South African Medical Journal. 1999;**89**(3):332-335

[60] Bamigboye AA, Hofmeyr GJ. Closure versus non-closure of the peritoneum at caesarean section: short- and long-termoutcomes. Cochrane Database of Systematic Reviews. 2014;(8):CD000163. DOI: 10.1002/14651858.CD000163.pub2

[61] Nagele F, Karas H, Spitzer D, Staudach A, Karasegh S, Beck A, et al. Closure or non closure of the visceral peritoneum at caesarean delivery. American Journal of Obstetrics and Gynecology. 1996;**174**:1366-1370

[62] Pietrantoni M, Parsons MT, O'Brien WF, Collins E, Knuppel RA, Spellacy WN. Peritoneal closure or nonclosure at caesarean. Obstetrics & Gynecology. 1991;**77**:293-296

[63] Shahin AY, Hameed DA. Does visceral peritoneal closure affect post-caesarean urinary symptoms? A randomized clinical trial. International Urogynecology Journal. 2010;**21**(1):33-41

[64] Anderson ER, Gates S. Techniques andmaterials for closure of the abdominal wall in caesarean section. Cochrane Database of Systematic Reviews. 2004;(4):CD004663. DOI: 10.1002/14651858.CD004663.pub2

[65] Hellums EK, Lin MG, Ramsey PS. Prophylactic subcutaneous drainage for prevention of wound complications after caesarean delivery—a metaanalysis. American Journal of Obstetrics and Gynecology. 2007;**197**:229-235

[66] Tuuli MG, Rampersad RM, Carbone JF, Stamilio D, Macones GA, Odibo AO. Staples compared with subcuticular suture for skin closure after caesarean delivery: A systematic review and meta-analysis. Obstetrics and Gynecology. 2011;**117**:682-690

[67] Mackeen AD, Berghella V, Larsen ML. Techniques and materials for skin closure in caesarean section. Cochrane Database of Systematic Reviews. 2012;(11):CD003577. DOI: 10.1002/14651858.CD003577.pub3

IntechOpen