Comparison between modified Misgav-Ladach and Pfannenstiel-Kerr techniques for Cesarean section: review of literature

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Abstract

In the last decades cesarean section rates increased in many countries becoming the most performed intraperitoneal surgical procedure. Despite its worldwide spread, a general consensus on the most appropriate technique to use has not yet been reached. The operative technique performed is made chiefly on the basis of the individual experience and preference of operators, the characteristics of patients, timing and urgency of intervention. We compared the two most known and used techniques, modified Misgav-Ladach and traditional Pfannenstiel-Kerr, and analyzed their impact on primary, short- and long-term outcomes and outcome related to health service use.

Key words: Pfannenstiel-Kerr, modified Misgav-Ladach, Joel-Cohen incision, Caesarean section.

Introduction

In 1916 Edward Cragin said "once a cesarean, always a cesarean", in the third millennium is this dictum still true? If we analyze the rate of cesarean section (CS) over the past decades, we find a rising trend worldwide, making CS the most performed intraperitoneal surgical procedure.
In Italy cesarean delivery increased from 11% in 1980 to 27.9% in 1996 to 38% in 2008; in United States CS reached a peak of 32.9% in 2009; in United Kingdom CS has increased from 9% in 1980 to 21% in 2000 and 24.8% in 2009 (1-3).
Cesarean section can be classified in planned (elective) or unplanned (emergency) and generally the indications are complex and multifactorial, concerning the safety of the mother, the baby or both. The main indications for planned CS are singleton breech presentation at term (in case of contraindicated or unsuccessful external cephalic version), twin pregnancy where the first twin is not cephalic, minor or major placenta praevia, infectious diseases (e.g. HIV, HCV, HBV, primary genital herpes simplex virus in the 3rd trimester), cephalopelvic disproportion and previous Cesarean section, but in the last decade the number of cesarean sections on maternal request dramatically increased. On the other hand, unplanned CS can be classified on the basis of the urgency (4 categories): a) category-1 CS (immediate threat to the life of the woman or fetus, delivery as soon as possible); b) category-2 CS (maternal or fetal compromise which is not immediately life-threatening, delivery within 75 minutes); c) category-3 (no maternal or fetal compromise but needs early delivery); d) category-4 (delivery timed to suit woman or staff) (4). Emergency CS has greater complication rates compared to a planned procedure.
Before the procedure women need to be assessed regarding age (years), parity, week of gestation, previous abdominal surgery or CS, estimated fetal weight, placental location. Also, it is fundamental to provide detailed and complete information about the proposed treatment, the intended benefits, serious and frequently occurring risks, possible complications, short- and long-term outcome for mother and newborn (5, 6).
Despite CS is a surgical routine procedure, a surgical consensus on the most appropriate operative technique or materials to use have not yet been reached. The operative technique performed is made chiefly on the basis of the individual experience and preference of operators, the characteristics of patients, timing and urgency of intervention (7). During planned

CS is not uncommon the Pfannenstiel abdominal entry and double-layer uterine closure, on the other hand Joel-Cohen abdominal entry are single-layer closure are preferred during emergency CS.
The aim of this review is to compare the two most common surgical techniques: Pfannenstiel-Kerr and modified Misgav-Ladach and their impact on primary, short- and long-term outcomes and outcome related to health service use (Tab. 1).

Results

We conducted a research on Pubmed, MEDLINE and COCHRANE from 2000 to 2015 using the keywords "Pfannenstiel-Kerr", "modified Misgav-Ladach", "Joel-Cohen incision", "Caesarean section". Among a total of 21,611 citations, we considered potentially eligible only 66 original studies, systematic reviews and meta-analysis, and National guidelines. We included in the review only the studies whom provided data about the two surgical techniques compared regarding the results on primary outcome (intraoperative and postoperative complications), mother secondary outcome (or short-term outcome), newborn short-term outcome, mother long-term outcome and outcome related to service use. We also took in great consideration the number and the type of suture materials used, as well as the duration of surgery (skin-to-skin), the time skin-to-delivery of the baby, the type of uterine closure (single *vs* double layer) and the possibility of scar defect and complications in future pregnancy.
Hudic et al. conducted a 9-year- prospective observational cohort study on 4,944 not randomized women undergoing primary planned and unplanned CS comparing the modified Misgav-Ladach (MML) technique with the classic Pfannenstiel-Kerr (PK) technique. The Authors divided the patient in 2 groups: MML (n = 4,336) and PK group (n = 608), analyzed duration of surgery, painkillers requirement, febrile morbidity, post-operative antibiotics requirement, postpartum endometritis, wound complications and hospitalization time. There were no statistical differences in the two groups, regarding maternal age, gestational age at delivery, parity, body mass index (BMI). The length of operative time (skin-to-skin) was significantly shorter in the MML group (13.3 ± 7.4 [mean ± SD], compared to PK group (19.1 ± 6.8), $P < 0.05$; less surgical materials were used in MML (3.5 ± 2.5 [mean ± SD]) *vs* 7.9 ± 2.1 in PK group, $P < 0.05$; women in MML required less analgesics (doses) 5.01 ± 4.7 *vs* 8.9 ± 1.4, $P < 0.005$. However, the MML group has a higher per-

Table 1. Cesarean section's outcomes classification.

Primary Outcome (intraoperative and postoperative complications)	**Mother short-term outcome**	**Newborn short-term outcome**	**Mother long-term outcome**	**Outcome related to health service use**
Organ damage (e.g. bladder and ureters, bowel, vessels)	Operating time	Time from skin incision to delivery	Long-term wound complications (e.g. numbness, keloids formation, incisional hernia)	Length of post-op hospital stay for mother and baby
Significant sepsis	Maternal death	Birth trauma	Pain	Readmission of mother or baby (or both) to hospital
Thromboembolism	Admission to ICU	Cord blood PH	Fertility problems	
Organ failure	Anemia	Apgar score	Complications in future pregnancies or surgeries (e.g. placenta praevia, placenta accreta, abruption, and uterine rupture)	
High Care Unit admission or death	Wound infection	NICU admission		
	Endometritis	Encephalopathy		
Blood transfusion	Time to mobilization	Respiratory problems		
	Time to oral intake of food and drink	Neonatal or perinatal death		
	Repeat operative procedure on the wound			
	Satisfaction with care			

centage of febrile morbidity (55% *vs* 40, P < 0.05) and wound infection (57% *vs* 7%, P < 0.05). No significantly statistical differences were noted regarding endometritis, wound infection, post-operative antibiotics and hospitalization time (days). A limitation of the study was the considerable discrepancy between the numbers of the two group (4,336 women in MML *vs* only 608 women in PK group), maybe due to a less confidence in the Pfannenstiel-Kerr technique by the surgical teams; moreover, the study did not provide any further information regarding maternal long-term outcome, especially fertility issues post CS, cesarean scar defects and uterine rupture in next pregnancies (8). Another study on 323 randomized women undergoing primary cesarean section (157 in Misgav-Ladach [ML] group and 162 in Pfannenstiel-Kerr [PK] group, without significant statistical difference on maternal characteristics and reasons for cesarean section) compared maternal outcome in the 2 groups. In ML group the duration of operating time, estimated blood loss (EBL), time to first bowel motion and post-operative mobilization were significantly lower in the ML group. Also, time to skin-to-delivery and Apgar score, neonatal admission to intensive care unit and death rates were better among the women in the ML group (9). Mathai et al. in their recent Cochrane review evaluated the benefits and risks of abdominal surgical incisions for cesarean section on 4 studies (666 women). Two trials, for a total of 411 women, compared Joel-Cohen with Pfannenstiel incision. In the Joel-Cohen group there was a 65% reduction in postoperative febrile morbidity (risk ratio [RR] 0.35%, 95% confidence interval [CI] 0.14 to 0.87) and one trial reported a reduced postoperative analgesic requirements (RR 0.55, 95% CI 0.40 to 0.76), as well as shorter operating time (-16.55 to 6.25 minutes) and delivery time (-2.53 to -1.27 minutes), EBL (-108.51 to -7.49 mL), shorter postoperative hospital stay for the mother (-2.16 to -0.84 days) (10). Another recent Cochrane review (Bamigboye AA et al.) assessed the short and long-term outcomes in closure *versus* non-closure of peritoneum during CS. The Authors evaluated 16 trials (15,480 women) about non-closure of visceral and parietal peritoneum *versus* closure of both parietal layers. In 4 trials (282 women) no difference was found between groups regarding postoperative adhesions formation (RR 0.99, 95% CI 0.76 to 1.29). The operating time was significantly reduced in the non-closure group (-5.81 minutes). However, the trials did not provide any additional information on long-term pain and infertility (11). Another Cochrane review by Dodd et al. analyzed the surgical techniques for uterine incision and uterine closure during CS. The Authors identified 27 randomized trials for a total of 17,808 women and analyzed the different types of uterine incision, the methods of performing the uterine incision, suture materials and technique of uterine closure (single *vs* double layer closure) on maternal health, infant health, and healthcare resource used on women undergoing CS. Five studies (2,141 women) compared blunt *versus* sharp dissection during uterine incision. No statistically significant differences were noted for febrile morbidity, but the need for blood transfusion was significantly lower in the blunt dissection group. One trial involving 9,544 women compared chromic catgut closure *vs* polyglactin-910 showing in the catgut group a significant reduction in the need for blood transfusion (RR 0.49% CI 0.32 to 0.76) and in complications requiring re-laparotomy (RR 0.58, 95% CI 0.37 to 0.89). Single layer *vs* double layer closure of the uterus was evaluated in 19 studies. In 9 studies (13,890 women) no significant differences regarding primary outcome and febrile morbidity were noted in both groups. However, the review did not provide any further clarification about long-term outcome or cesarean scar defects, (12). Roberge et al. analyzed 9 studies including 5810 women, finding a higher risk of uterine rupture after a locked single layer repair of hysterotomy (OR 4.96; 95% CI 2.58-9.52, P <0.001) than in unlocked single and double layer closure (13). Staples, interrupted stitches and subcuticular suture are the most common methods for skin closure, a Cochrane review (Mackeen et al.) analyzed the techniques and the materials used for re-approximation of the skin incision with the aim to identify which materials and technique provide the best outcome for women. On 19 trials included, the Authors collected data from only 8. The most compared skin closure methods are non-absorbable staples and absorbable subcutaneous sutures. The Authors found similar incidences of wound infection in the two groups and also no great differences among classical Pfannenstiel incision compared to Joel-Cohen. Compared with absorbable subcuticular suture, non-absorbable staples presented an increased risk of skin separation, especially if removed before the 4th postoperative day. Both skin closures presented similar outcomes regarding pain and cosmetic aspect (14). A retrospective cohort study on 149 women undergoing their first elective CS compared residual myometrial thickness (RMT) and size of cesarean scar defect after single- and double-layer uterine closure. Women with type 1 diabetes mellitus, previous myomectomy, endometritis, postpartum complications and no information on number of hysterotomy layers were excluded from the study. A transvaginal ultrasound was performed between 6 and 15 months after the surgery. Mean RMT was 5.8 mm (range 4.1-7.8) in double-layer suture group and 4.6 mm (range 3.4-6.5) in single-layer group, but the number of women with RMT <2.3 m [suggested to be associated with a higher risk of uterine rupture in a trial of labor (15)] did not show significant statistical difference. Among women with a scar defect, the median defect length was significantly greater after single-layer compared with double-layer closure (P =0.01), but no significant difference were noted in median defect depth or width among the two groups. Women with anteverted uteri in the single layer group presented a significantly smaller RMT (P =0.003) compared to double-layer group (16).

O'Neill et al. conducted a systematic review and meta-analysis on the effects of cesarean delivery on fertility on 11 articles. Compared to women with a vaginal de-

livery, cesarean delivery was associated with an increased risk of sub-fertility (OR 0.90; 95% CI 0.86-0.93), possibly due to infection at the site of the wound, scar adhesion and placental bed disruption. The Authors noticed that among women who underwent Cesarean delivery the interpregnancy interval, defined as the period since the termination of the previous pregnancy and conception of the next pregnancy, was longer compared to woman who delivered vaginally (22 months *vs* 16 months). It is also possible a deliberately delaying of pregnancy among women who delivered by CS. The Authors of this systematic review did not compare any cesarean surgical technique (17).

Discussion

The modified Misgav-Ladach method has been proposed in the '90s by Stark et al. on the basis of Joel-Cohen laparotomy, described initially for hysterectomy (18). Compared to traditional Pfannenstiel-Kerr cesarean section, Misgav-Ladach method proved to have several advantages such as shorter operating time, less use of suture materials, less blood loss, as well as less post-operative pain and less wound infection. The purpose of the technique is to be a faster and less traumatic as possible procedure, avoiding when and where possible the classic instrumental sharp dissection. For its characteristics, this technique has been defined "gentle cesarean section". Several studies proved modified Misgav-Ladach technique is feasible and efficient, being faster method of delivering the fetus than both Pfannenstiel-Kerr and midline incisions and having less short-term maternal comorbidities (Tab. 2). On the basis of the results, it seems consistent preferring Misgav-Ladach technique in case of emergency cesarean section when even a minute can be precious, but it proved to be a working technique also in planned CS. Even though, several studies confirmed the efficiency of the technique concerning maternal short-term outcomes, further evidences are needed about long-term outcomes, in particular re-

Table 2. Description of Pfannestiel-Kerr and modified Misgav-Ladach techniques of cesarean section (8, 9, 17-20).

Pfannenstiel-Kerr technique	Modified Misgav-Ladach technique
Opening Skin transverse incision 2-3 cm above the symphysis pubis, 8-12 cm long that curves gently upward ("smiley incision"). Subcutaneous tissue and abdominal rectus muscles are separated by sharp incision of the internal oblique and transverse muscles fascia. The anterior fascia and linea alba are separated in the midline in a cranial direction (from symphysis to umbilicus). The parietal peritoneum is opened by sharp dissection. Visceral peritoneum overlying the uterus is grasped with forceps just above the superior margin of the bladder and incised with Metzenbaum scissor. The lower uterine segment is incised with a scalpel approximately 2 cm above the vesico-uterine fold until membranes bulge, then the surgeon extends the incision laterally with curved scissor, using index finger as an elevator. Delivery of placenta by manual removal.	*Opening* Skin transverse incision 3-4 above the symphys pubis, for a variable length of 15 to 17 cm. The subcutaneous tissue is left undisturbed apart from the midline. The rectus sheath is separated along its fibers and rectus muscles are separated by pulling. The parietal peritoneum is opened digitally at the upper level of the intermuscular space and stretched in a cranial-caudal direction. A retractor is inserted to facilitate access to the lower uterine segment and a small transverse incision is made with a scalpel, 2 cm above the vesico-uterine fold until the membranes bulge and the two index fingers are inserted to stretch the opening laterally. Delivery of placenta by controlled cord traction.
Uterus closure Uterus is not exteriorized. The incision is repaired in two layers with continuous unlocked sutures. It is suggested the use of a delayed absorbable monofilament (Monocryl).	*Uterus closure* Uterus is exteriorized and the incision is repaired in one layer with a continuous unlocked suture. It is suggested the use of a delayed absorbable monofilament (Monocryl).
Abdominal and skin closure Visceral and parietal peritoneum are closed with a continuous suture (no. 2-0, Vicryl). Rectus muscles with three to five interrupted stitches (no. 2-0, Vicryl). The transversely incised fascia is closed with a continuous locked suture (no. 1-0 polyglactine suture). Subcutis is sutured in interrupted stitches (no. 2-0 Vicryl). Skin may be closed with subcuticular suture.	*Abdominal and skin closure* Visceral and parietal peritoneum are left open and muscles are not approximated. Fascia is closed with a continuous unlocked suture (no. 1 Vicryl). The skin is closed with widely spaced sutures, generally three stitches (no. 2-0 polyester or silk), and the margins between the stitches are approximated with four Allis clamps for 5 min.
Postpartum care Intravenous hydration on the day of intervention. Catheter removal on the 2nd postoperative day. Oral fluids are commenced with the return of normal bowel movements (usually 24h after the operation) and a light diet is enabled 48 h after the intervention. Stitches are removed on the 7th postoperative day.	*Postpartum care* Intravenous hydration on the day of intervention. Early ambulation is encouraged 8h after the procedure. Catheter removal on the 1st postoperative day. Oral fluids are commenced 12h after the operation and a light diet is enabled 24h after the intervention. Stitches are removed on the 5th to 7th postoperative day.

garding cesarean scar defect, pregnancy implantation at a previous cesarean scar (cervicoisthmic implantation), rupture of the uterus and secondary infertility which are increasing following the rise in cesarean rate, especially in patients with multiple previous CS (21). Single-layer uterine closure may be more likely to result in uterine rupture especially if the suture is locked and birth weight is greater than 3,500 g (13, 16, 22), so it seems sensible to performed a double closure to prevent uterine rupture and to improve safely the rates of trial of labor (TOL) and vaginal birth after cesarean (VBAC). Double-layer uterine closure combining the surgical approximation of decidua followed by the approximation of myometrium with myometrium seems to be associated with a reduction in uterine scar defects compared with single-layer uterine closure including the decidua into the suture (23). Risk factor for uterine rupture is multiple prior cesareans, locked single-layer uterine closure, short inter-pregnancy interval and previous preterm cesarean. Transvaginal ultrasound demonstrated to be a very useful tool to evaluate uterine scar and residual myometrial thickness in women at risk for uterine rupture (22, 24). A meticulous first-trimester transvaginal ultrasonographic with color flow Doppler can successfully identified an abnormally adherent trophoblastic pregnancy, in which the embryo implants within the myometrium, from a normally implanted pregnancy in patients with a cesarean scar defect (25). A delay in diagnosis or an expectant management in case of cesarean scar ectopic pregnancy can lead to life threatening conditions such as uterine rupture and severe hemorrhage resulting in hysterectomy (26).

Even if women with previous CS are at higher risk in subsequent pregnancy compared with whom with a previous vaginal delivery, it is important to underline that trial of labor and vaginal birth is a reasonable option in low-risk patients with one previous transverse low-segment CS (27); however, an appropriate discussion of maternal and perinatal risks and benefits is mandatory. The woman should deliver in a hospital where a continuous electronic fetal monitoring and if necessary a timely CS are promptly available. Suspected uterine rupture in labor requires urgent attention and expedited laparotomy to attempt to decrease maternal and perinatal morbidity and mortality. Since Prostaglandin E1 (misoprostol) has been associated with a higher risk of uterine rupture it should be avoided and oxytocin should be used carefully, on the other hand there is no contraindication for sweep of membranes (28). A predictive factor for a successful trial of labor and vaginal birth seems to be a greater RMT evaluated from first to second trimester. So in women suitable for VBAC we strongly recommend an early transvaginal ultrasonographic evaluation of residual thickness (29).

Conclusion

The choice of the Cesarean section technique is strictly linked to the individual experience and confidence of the surgical team. On the basis of the studies reviewed, Misgav-Ladach modified technique proved to be associated to less short- and long-term complications, moreover, since its shorter operating time, it is to prefer in all that cases a prompt operation is required. However, the most controversial aspect remains the single *vs* double layer uterine closure, in regards of the association between single layer and possible uterine rupture. Waiting for more studies to prove the efficacy and safety of single layer uterine closure, especially in relation to long term outcomes, we recommend a double-layer uterine closure or in alternative an unlocked single layer (4, 13, 16, 22, 23). Concluding, to identify the safest and most appropriate surgical technique for both mother and newborn in order to minimize morbidity, postoperative pain, ensuring the best possible short and long-term outcomes for both mother and child, minimizing the risk of cesarean scar defects and uterine rupture, and allowing vaginal delivery in the next pregnancy is the main goal of future obstetrics and the first step to pragmatically reduce the rate of cesarean sections.

Conflict of interest

No Author has any potential conflict of interest.

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