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Cesarean delivery: Technique

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Page 4: INTRAABDOMINAL PROCEDURES / C SAFE; "a surgical device specifically designed to reduce the risk of lacerating the fetus at hysterotomy"

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INTRODUCTION — As with most surgical procedures, there is no standard technique for cesarean delivery. The following discussion will review each step in the procedure and provide evidence-based recommendations for surgical technique, when these data are available.

OPENING THE ABDOMEN

Skin incision

Transverse or vertical — The advantages and disadvantages of various incisions and the procedure for opening the abdomen from skin to peritoneum are the same as for gynecologic procedures, and are described separately. (See "Principles of abdominal wall incisions".)

In general, a transverse (eg, Pfannenstiel or Joel-Cohen) incision is most commonly used for cesarean delivery since it is associated with less postoperative pain, greater wound strength, and better cosmetic results than the vertical midline incision [1]. However, vertical incisions generally allow faster abdominal entry [2], cause less bleeding and nerve injury, and can be easily extended cephalad if

more space is required for access. Randomized trials have not evaluated outcomes related to the choice of skin incision separately from other aspects of cesarean delivery. A prospective cohort study including over 3500 emergency cesarean deliveries confirmed that median incision to delivery intervals were faster for vertical than transverse skin incisions (3 versus 4 minutes for primary cesareans and 3 and 5 minutes for repeat cesareans) [2]. However, neonatal outcomes were not improved and some maternal and neonatal outcomes were worse in the vertical incision group (eg, need for postpartum maternal transfusion [8.5 versus 5.3 percent], neonatal intubation in the delivery room [17 versus 13 percent]); this was attributed to unidentified confounders.

At all stages of the cesarean procedure, we prefer using the scalpel for sharp dissection, rather than an electrocautery device. There are no randomized trials comparing scalpel to electrocautery during cesarean delivery. The bulk of evidence from observational studies shows that neither scalpel nor electrosurgery holds a significant benefit over the other; either approach is acceptable. Of note, it probably isn't necessary to change to a fresh scalpel blade after opening the abdomen [3]. (See "Principles of abdominal wall incisions", section on 'Skin incision'.)

Size — The size of the abdominal skin incision needs to be adequate for easy delivery of the fetus. While there are no trials on this technical aspect of cesarean delivery, a 15 cm long incision (the size of a standard Allis clamp) is probably the minimal length that allows atraumatic and expeditious delivery of the term fetus [1].

Subcutaneous tissue layer — There are no randomized trials comparing techniques for incision and dissection of the subcutaneous tissues at cesarean delivery. We prefer blunt dissection (with fingers) to sharp dissection (with the knife), as blunt dissection has been associated with shorter operative times and less chance of injury to vessels [4,5].

Fascial layer — There are no randomized trials comparing different techniques of opening the fascia at cesarean delivery. A small transverse incision is usually made medially with the scalpel, and then extended laterally with scissors. Alternatively, the fascial incision can be extended bluntly by inserting the fingers of each hand under the fascia and then pulling in a cephalad-caudad direction, sometimes referred to as part of the Joel-Cohen or Misgav-Ladach techniques (see 'Alternative techniques' below) [1,4].

Rectus muscle layer — Rectus muscles can be separated bluntly in most cases, avoiding transection of muscles preserves muscle strength [6-8]. Dissection of the rectus fascia from the rectus sheath and muscles seems to be unnecessary [4,5,9], but has not been studied separately in a randomized trial.

Opening the peritoneum — We, and others [4,5,9], favor using the fingers to bluntly open the peritoneum to minimize the risk of inadvertent injury to bowel, bladder, or other organs that may be adherent to the underlying surface. Blunt versus sharp entry into the peritoneum has not been compared in a randomized trial.

Dense intraperitoneal adhesions — If there are dense adhesions between the anterior abdominal wall and the anterior surface of the uterus, we enter the peritoneum bluntly and as close as possible to the upper abdomen to avoid areas of dense scar tissue in the lower abdomen (pelvis). Sharp dissection also may be needed, and should be done cautiously using shallow incisions under direct vision. If pelvic adhesions require extensive dissection with risk of injury to the bowel, urinary tract, or major blood vessels in order to expose the lower uterine segment, and the patient desires tubal ligation, we avoid or minimize adhesiolysis and perform the hysterotomy in the most appropriate accessible location. A case report in which the entire length of the ventral aspect of the uterus and bladder was densely adherent to the rectus sheath described extending the vertical incision above the level of the adhesions and then entering the uterine cavity through an incision across the fundus [10].

Another option is a paravesical or supravesical extraperitoneal approach [11]. Most obstetricians are not familiar with this technique since it was used primarily in the pre-antibiotic era to decrease the risk of intraperitoneal infection. It requires a detailed knowledge of the relationship between the fascial

planes and the bladder and lower uterine segment. In experienced hands, it may provide a means of avoiding dense midline adhesions.

A surgeon experienced in complex abdominal surgery should be present if meticulous dissection of dense adhesions involving important structures is needed. Insertion of ureteral stents can be useful to facilitate intraoperative identification (and avoidance) of the ureters.

Assuring adequate exposure — The full thickness abdominal incision should be adequate to allow delivery of the fetus. The surgeon and an assistant together can manually stretch apart the opening at the angles of the incisions, but additional sharp dissection may be necessary.

Issues in obese women — Cesarean delivery of the morbidly obese woman is reviewed separately. (See "Cesarean delivery of the obese woman" and "The impact of obesity on fertility and pregnancy".)

INTRAABDOMINAL PROCEDURES

Bladder flap — We do not routinely create a bladder flap. In two trials that randomly assigned women to undergo or not undergo development of a bladder flap, omitting this procedure reduced the incision-to-delivery interval by an average of one to two minutes and was not associated with an increase in adverse short-term outcomes [12,13]. However, the long-term consequences of this intervention have not been evaluated.

Some obstetricians choose to selectively perform a bladder flap if a difficult delivery is anticipated, such as when the fetal head is deep in the pelvis or when the bladder is attached well above the lower uterine segment after a previous cesarean delivery. In these cases, creation of the bladder flap may help to keep the bladder dome out of the surgical field if the uterine incision extends.

The location of the bladder is best delineated by palpating the catheter, if present. The demarcation between the lower and upper uterine segments is difficult to make clinically, sonographically, or histologically. The location or level of the demarcation also changes based on the clinical situation. In some patients, such as those who are not in labor, it may not be possible to make an incision in the lower uterine segment without first creating a bladder flap.

Hysterotomy — Prior to making a hysterotomy incision, the surgeon should be aware of the general location of the placenta and the fetal lie. Leopold maneuvers or ultrasound can be used to obtain this information, which helps avoid lacerating the placenta and in delivery of the fetus.

The uterine incision may be transverse or vertical; no randomized trials have compared the two techniques. The type of incision depends upon several factors, including the position and size of the fetus, location of the placenta, presence of leiomyomas, and development of the lower uterine segment. The principal consideration is that the incision must be large enough to allow atraumatic delivery of the fetus.

Transverse incision — For most cesarean deliveries, we recommend using a transverse incision along the lower uterine segment (ie, Monroe-Kerr or Kerr incision). Compared with vertical incisions, advantages of the transverse incision include less blood loss, less need for bladder dissection, easier reapproximation, and a lower risk of rupture in subsequent pregnancies [1].

The major disadvantage of the transverse incision is that significant lateral extension is not possible without risking laceration of major blood vessels. A "J" or inverted "T" extension is often required if a larger incision is needed. This can be problematic because the "J" extension goes into the lateral fundus and the angles of the inverted "T" incision are poorly vascularized, both of which potentially result in a weaker uterine scar.

Low vertical and classical incisions — There are two types of vertical incisions, the low vertical (Kronig, De Lee, or Cornell) and the classical vertical. The low vertical is performed in the lower uterine segment and appears to be as strong as the low transverse incision [14]. The major disadvantage of the low vertical incision is the possibility of extension cephalad into the uterine fundus or caudally into the bladder, cervix, or vagina. It is also difficult to determine that the low vertical incision is truly low, as the separation between lower and upper uterine segments is not easily identifiable clinically.

A vertical incision that extends into the upper uterine segment/fundus is termed a "classical" incision. This incision is rarely performed at or near term because in subsequent pregnancies it is associated with a higher frequency of uterine dehiscence/rupture (4 to 9 percent) compared with low vertical (1 to 7 percent) and low transverse (0.2 to 1.5 percent) incisions; it is also associated with more maternal morbidity [15,16]. Whether a vertical incision is confined to the lower, noncontractile portion of the myometrium (low vertical) or extends into the upper contractile portion of the myometrium (classical) is a subjective assessment; an objective method for differentiating between the two types of uterine incisions has not been determined. (See "Choosing the route of delivery after cesarean birth", section on 'Uterine rupture'.)

The generally accepted indications for considering a vertical uterine incision are:

- Poorly developed lower uterine segment in a setting in which more than normal intrauterine manipulation is anticipated (eg, extremely preterm breech presentation, back down transverse lie)
- Lower uterine segment pathology that precludes a transverse incision (eg, large leiomyoma, anterior placenta previa or accreta)
- Densely adherent bladder
- Postmortem delivery

Bandl's ring — A constriction ring of the uterus, called Bandl's ring, is a rare complication of labor. The constriction forms between the upper contractile portion of the uterus and the lower uterine segment, and often leads to cesarean delivery because of dystocia. It may occur between delivery of the first and second twin. At laparotomy, a transverse thickened muscular band can be observed separating the upper and lower segments of the uterus. There is sparse information on the best management of Bandl's ring noted at cesarean delivery. Its presence is not an absolute indication for a vertical uterine incision, as transecting the ring may or may not allow easy delivery of the fetus. Intravascular injection of nitroglycerin (50 to 200 mcg) can be administered to relax the uterus if the fetus is difficult to extract [17-19].

Procedure — A scalpel is used to perform the initial part of the hysterotomy. Various techniques are employed to minimize the risk of fetal injury during the myometrial incision. All involve elevating and carefully thinning the inner myometrial and decidual layers to minimize bleeding, maximize exposure, and promote separation of the uterine tissue from the fetal membranes or skin.

One technique is to apply Allis clamps to the superior and inferior edges of the myometrial incision and elevate them. Another is to remove the suction tip and directly apply the end of the suction tubing to the center of the myometrial incision to balloon-out and thin-out this layer while providing easily identifiable, relatively blood-free exposure. If possible, membranes are left intact until complete extension of the incision [20]. A third option is to use a surgical device specifically designed to reduce the risk of lacerating the fetus at hysterotomy (eg, C-safe®).

When entry into the uterine cavity is achieved, the hysterotomy incision can be extended using bandage scissors or blunt expansion with the surgeon's fingers. Three randomized trials compared these two techniques [16,21,22]; two trials found sharp dissection was associated with greater blood loss [16,22], while the other reported the two techniques were equivalent [21]. Extensions of the uterine incision (defects occurring outside the line of the original incision) were less common in the sharp extension group, but the difference was not statistically significant in two of the three trials. We suggest blunt expansion because it is fast and has less risk of inadvertent trauma to the fetus, and it may reduce blood loss and extension of the incision. Extending the uterine incision transversely by

pulling vertically (cephalocaudal) with the index fingers reduces the risk of unintended extension and excessive blood loss [9,23].

In four trials, the use of absorbable staples for extension of the hysterotomy and later closure was associated with a slightly longer time to deliver the baby and no benefits in maternal or perinatal outcomes compared with the traditional method [24]. This technique should be reserved for rare indications (eg, ex utero intrapartum treatment [EXIT] procedure).

Delivery — Hysterotomy extensions, particularly those involving the cervix, occur more frequently if the cesarean is performed after a prolonged second stage of labor [25]. Attenuation of the lower uterine segment and impaction of the fetal head are common in this setting and warrant increased care during delivery of the fetal head and shoulders.

To deliver a fetus in cephalic presentation, the surgeon inserts his/her hand into the uterine cavity to flex the fetal head and bring it to the level of the uterine incision, from which it can be extracted. Transabdominal fundal pressure is usually applied by the surgical assistant. A set of forceps or a vacuum device should be available in the operating room to assist with flexing the head and guiding it through the incision if this is difficult, but routine use of these instruments is not recommended since they may increase morbidity [26-28].

A deeply impacted fetal head can be hard to disengage and deliver. The "push" method involves the operator or an assistant pushing the head back through the vagina and out of the pelvis; the "pull" or "reverse breech" method has the surgeon grasp the fetal legs in the upper uterine segment and extract the fetus by the breech. The pull method appears to have lower maternal and neonatal morbidity than the push method [29-31]. However, in some cases, it is necessary to extend the hysterotomy incision into an inverted 'T" or a "J" shape to deliver the fetus, as a large incision is required.

Most studies, but not all [32,33], have reported a direct association between a prolonged uterine incision-to-delivery time and lower fetal blood gas pH values and Apgar scores, regardless of type of anesthesia [34]. The mechanism is thought to be hysterotomy induced increased uterine tone, which can interfere with uteroplacental blood flow. Thus, careful attention to the duration of this interval by the surgeon is important, especially in a fetus with a nonreassuring fetal heart rate assessment prior to the onset of surgery.

Delivery of the fetus in breech or transverse presentation is discussed separately. (See "Delivery of the fetus in breech presentation" and "Management of the fetus in transverse lie".)

Cord clamping and infant assessment — Delayed, rather than immediate, cord clamping results in greater neonatal hemoglobin levels and appears to be beneficial for both preterm and term infants. (See "Management of normal labor and delivery", section on 'Cord clamping' and "Management of normal labor and delivery", section on 'Cord blood'.) The health benefits for delayed cord clamping (eg, slight increase in hemoglobin) of term infants in developed countries may not be as clinically meaningful as in developing countries.

An appropriately trained clinician should be present to care for the infant [35]. The degree of training depends upon the presence and type of risk factors for neonatal complications. (See "Overview of the routine management of the healthy newborn infant".)

Antibiotic prophylaxis — Antibiotic prophylaxis used to be administered after cord clamping to prevent interference with neonatal cultures, but antibiotics are now administered to the mother preoperatively. (See "Cesarean delivery: Preoperative issues", section on 'Antibiotic prophylaxis'.)

Placental extraction — Draining the placenta prior to extraction appears to result in less fetomaternal transfusion [36]. Spontaneous extraction (gentle traction on the cord and use of oxytocin to enhance uterine contractile expulsive efforts) should be performed, instead of manual extraction, because

several randomized trials have shown that manual extraction results in more postoperative endometritis (RR 1.64, 95% CI 1.42-1.90), greater blood loss (weighted mean difference 94 mL, 95% CI 17- 172 mL), more women with blood loss over 1000 mL (RR 1.81, 95% CI 1.11-2.28), and lower postpartum hematocrit [37]. There is no need to change gloves before removal of the placenta [38].

To ensure that all of the placenta has been removed, the uterus is usually explored with one hand holding a sponge to remove any remaining membranes or placental tissue, while the other hand is placed on the fundus to stabilize the uterus. These manipulations further stimulate uterine contraction.

Prevention of hemorrhage — As soon as the placenta is delivered, the uterus is massaged to promote contraction, which is the main mechanism for reduction of uterine bleeding. Oxytocin is administered intravenously to promote uterine contraction and involution [39-41]. The term uterus is very sensitive to oxytocin; most patients at scheduled cesarean delivery will achieve satisfactory contraction of the uterus after an intravenous oxytocin dose no larger than 1 U over 10 seconds [40]. (See "Uterotonic drugs for management of the third stage of labor".)

It is unclear whether the best oxytocin regimen is a bolus injection, continuous infusion, or a combination of both. The optimum timing, dose, and duration of therapy have not been studied extensively, and may differ depending on whether or not the patient has labored:

- If only an oxytocin infusion is given, the initial infusion should probably be at least 10 U over 30 minutes. In one randomized trial including over 300 laboring women who underwent cesarean delivery, an oxytocin infusion of 80 units in 500 mL Lactated Ringer's over 30 minutes after delivery of the infant was associated with a lower need for another uterotonic agent than a 10 unit dose in 500 mL Lactated Ringer's over 30 minutes, but there were no differences in change in hematocrit [42]. Intermediate doses were not evaluated. After the initial dose, all patients also received 20 U of oxytocin in 1 L of Lactated Ringer's solution at a rate of 125 mL/h for eight hours.
- If only a bolus is given, no more than a 5 U oxytocin over several minutes is needed to prevent hemorrhage. One trial randomly assigned 40 women undergoing scheduled cesarean delivery to receive oxytocin 5, 10, 15, or 20 units at a rate of 1 U/min immediately after clamping of the umbilical cord, without routine subsequent infusion [41]. Estimated blood loss and postpartum change in hematocrit were similar for all four groups, suggesting there is no benefit to administering more than 5 U of intravenous oxytocin to term parturients undergoing elective cesarean delivery.
- Combined therapy (bolus and infusion) appears to be unnecessary. A randomized trial found that a bolus injection of oxytocin 5 U over 30 seconds before beginning an oxytocin infusion was not more effective than an infusion alone in reducing the subsequent need for uterotonic drugs to prevent or treat postpartum hemorrhage [43].

For most patients, after cord clamping we administer 20 to 40 units of oxytocin in 1 liter of normal saline over an hour. We give another 1 to 3 liters of the same solution at 125 mL/hour, then discontinue the oxytocin, and also the intravenous fluids if oral hydration has been established.

Of note, carbetocin has been associated with lower need for additional uterotonics compared to oxytocin, but this drug is not widely available [44,45].

PROCEDURES DURING CLOSURE

Exteriorizing the uterus — We, and many others, exteriorize the uterus to improve exposure and facilitate closure of the hysterotomy. A meta-analysis of the first six randomized trials (n = 1294 women) on uterine exteriorization found that extra-abdominal closure of the uterine incision was associated with lower febrile morbidity (RR 0.41, 95% CI 0.17-0.97) and longer hospitalization (weighted mean difference 0.24 days, 95% CI 0.08-0.39), but there were no significant differences in other outcomes (eg, blood loss, postoperative change in hematocrit, endometritis, wound complications, analgesia requirements, length of surgery) [46]. There was insufficient evidence to conclude that one approach was superior the other, and that more data were needed.

Subsequent to this meta-analysis, three additional randomized trials assessing uterine exteriorization versus repair in situ have been published [47-49]. Taken together, these nine trials suggest there is no clinically significant difference in outcome between the two techniques, although exteriorization may be associated with shorter operating time [49], more nausea [48], and more pain on the first postoperative day [47,49]. Therefore, the surgeon should choose the technique based on individual clinical circumstances and personal preference.

Uterine closure — Routine manual/instrumental cervical dilatation before closing the uterus in an elective cesarean delivery is unnecessary. Controlled studies have reported that this practice does not improve postoperative hemoglobin levels or reduce the incidence of fever or wound infection [50].

Suture — For closure of the uterine incision, there are no high quality data to guide choice of suture material (eg, chromic catgut versus delayed absorbable synthetic [eg, polyglactin 910, poliglecaprone 25]) or technique (eg, continuous [locked or nonlocked] versus interrupted) [51]. A 0- delayed absorbable synthetic monofilament (eg, Monocryl®) or braided (eg, Vicryl®) suture is commonly used in the United States. A new type of suture, barbed suture, has been used successfully for knotless closure of myomectomy incisions [52,53] and skin closure of the Pfannenstiel incision during cesarean delivery [54].

Myometrial closure — When performing uterine closure, we usually perform a two-layer, continuous closure with delayed absorbable synthetic suture incorporating all of the muscle in order to avoid bleeding from the incision edges. We do not use locking sutures unless arterial bleeding is evident.

The endometrial layer should probably be included in the full thickness myometrial closure. This opinion is based on a randomized trial that assigned 78 term pregnant patients delivered by cesarean to one layer myometrial closure either including or excluding the endometrial layer [55]. The frequency of a wedge-type healing defect by ultrasound six weeks postpartum was significantly lower in the group treated by full thickness suturing (45 versus 69 percent). Outcomes in subsequent pregnancies were not evaluated, so the clinical significance of this finding is unknown.

Use of blunt tip needles during closure is associated with similar maternal outcomes as use of sharp needles, but is safer for the surgeon (glove perforation rate 7.2 versus 17.5 percent with sharp needles [56]) [56,57]. However, in some studies physicians were less satisfied with the performance of blunt needles [56].

Single versus double layer closure — A low transverse uterine incision can be closed in a single layer to decrease operating time [51]; however, there is conflicting evidence regarding the long-term safety of this approach.

In the short-term, a large randomized trial (CAESAR) of women undergoing their first cesarean delivery found no difference between those who underwent single versus double layer uterine closure in the rate of infectious morbidity, severity of postpartum pain, or need for blood transfusion [58].

In the long-term, however, concerns have been raised that patients who undergo a single layer closure may be at increased risk of uterine rupture during the next pregnancy compared with those who undergo a two-layer closure [59-61]. This concern was addressed by a systematic review of studies (6 cohort, 2 case-control, 1 randomized trial; 5810 women) that compared the risk of uterine rupture during a trial of labor (TOL) after single versus double layer closure of a first cesarean delivery [62]. Uterine rupture was defined as complete scar separation necessitating an emergency intervention. The risk of uterine rupture during TOL after a single layer closure was not significantly different from that after a double-layer closure (OR 1.71, 95% CI 0.66-4.44). However, the technique used for the single layer closure appeared to be an important factor. A locked single layer closure was associated with a significantly greater risk of rupture than a double layer closure (OR 4.96, 95% CI 2.58-9.52), while an unlocked single layer closure did not increase the risk of rupture (OR 0.49, 95% CI 0.21-1.16).

The risk of uterine rupture after single versus double layer uterine closure warrants further study in a well-designed randomized trial, given the limitations of the studies in this meta-analysis. Most of the studies were retrospective, no study directly compared outcomes of locked versus unlocked single layer closure, ascertainment of the technique for single layer closure was based on usual practice at the study site rather than documentation in patient records, and the type of suture material was not considered.

We suggest a two-layer uterine closure, even though data supporting this opinion are inconclusive. Given the available data, either a one layer or two layer closure technique is within acceptable standards of medical practice; we suggest an unlocked technique for one layer closure. A double (or even triple) layer closure may be necessary when the myometrium is thick, such as with a classical and some low vertical incisions.

Uterine rupture-dehiscence is the major long-term outcome of single versus double layer closure that has been studied. There is a paucity of data on other long-term outcomes. A secondary analysis of data from a prospective study of women undergoing repeat cesarean delivery observed an increased risk of bladder adhesions in women who had undergone single layer closure [63]. Further study of possible adverse consequences of single layer closure is warranted.

Closure of a classical incision — There are no trials comparing techniques for closure of the thick myometrium of the fundus. We use continuous sutures to close the inner myometrial layer; others prefer interrupted sutures, including interrupted vertical figure of eight sutures. It is useful to have an assistant manually reapproximate the incision by pushing the myometrium on each side toward the midline as each suture is placed and tied. This reduces tension on the incision and helps prevent the suture from tearing through the myometrium, especially when closing the first layer. A second layer is used to close the mid-portion of the thick myometrial layer, leaving about 1 cm of outer myometrium still open. We then close the serosa and outer layer using a baseball stitch, which is hemostatic and minimizes exposed raw surfaces, and thus may reduce adhesions.

Abdominal irrigation — Intraabdominal irrigation after closure of the uterus does not reduce maternal infectious morbidity beyond the reduction achieved with prophylactic intravenous antibiotics alone [64,65]. In one trial, the irrigation increased intraoperative nausea [65].

Adhesion barriers — Formation of adhesions is common after cesarean delivery; rates from 11 to 70 percent have been reported [66]. The rate of bowel obstruction after cesarean delivery is much lower, ranging from 0.5 to 9 per 1000 cesarean deliveries, with the highest risk in women who have undergone multiple cesarean deliveries [66-68].

There are no randomized trials evaluating the effectiveness of adhesion barriers in this procedure. One group estimated that women increase their risk of small bowel obstruction by 0.1 percent by undergoing cesarean delivery and that adhesion barriers may mitigate this risk by 50 percent [69]. Based on these assumptions, 2000 women would need to have an adhesion barrier placed at cesarean delivery to avoid one bowel obstruction and the cost per small bowel obstruction averted would be several hundred thousand dollars. Available evidence does not support the routine use of adhesion barriers in women undergoing cesarean delivery.

Peritoneum — We do not close the visceral or parietal peritoneum. There is high quality evidence from randomized trials that peritoneal nonclosure decreases operative time [70-73], and has a similar rate of maternal infectious morbidity as closure [58].

The effect of nonclosure on adhesion formation is less clear because of the small number of patients who have undergone follow-up at a second cesarean delivery. Nonclosure might allow the enlarged uterus to adhere to the anterior abdominal wall or impede spontaneous closure of the peritoneum, while closure might cause a foreign body reaction to sutures and tissue damage.

Several studies have attempted to evaluate this issue and have reported conflicting results [71,74-81]. A systematic review of peritoneal nonclosure and adhesion formation after cesarean delivery found some evidence that nonclosure was associated with greater adhesion formation than closure of the parietal layer or both visceral and parietal layers (OR 2.6, 95% CI 1.48-4.56; three studies, n = 249) [82]. The studies were included if the primary objective was to examine adhesion formation in a repeat cesarean delivery, had a clear study design, had an adhesion scoring system, and excluded patients who had adhesions at the primary cesarean or who had interim surgeries after the primary cesarean. Many studies were excluded from this review because of poor methodologic design or clinical heterogeneity. Another systematic review that included many of these studies also found that nonclosure was associated with greater adhesion formation [83].

Subsequent to these analyses, a large well-designed trial that randomly assigned 533 women at primary cesarean to peritoneal nonclosure or closure found no significant difference between groups in the proportion of patients with adhesions at any site or time from incision to delivery at repeat cesarean (n = 97 repeat cesareans) [80]. Strengths of this trial included that its primary objective was to examine adhesion formation in a repeat cesarean delivery, use of an adhesion scoring system, exclusion of patients who had had prior pelvic or abdominal surgery, use of a standard technique for performing the cesareans, and blinding the surgeon performing the repeat cesarean to patient allocation.

At this time, we believe there is good evidence for the benefit of nonclosure (decreased operating time) and inadequate evidence of harm (increased adhesion formation).

Rectus muscles — Most clinicians believe that the rectus muscles reapproximate naturally and suturing them together may cause unnecessary pain when the woman starts to move after surgery [1]. No randomized trial has evaluated rectus muscle closure versus nonclosure. A prospective observational study reported a reduction in dense adhesion formation when the rectus muscles were reapproximated; however, this study did not assess pain or hematoma formation potentially related to this intervention and could not fully adjust for other intraoperative interventions, such as peritoneal closure [81].

Fascia — The method of fascial closure is a critical aspect of incisional closure, as this provides the majority of wound strength during healing. Care should be taken to avoid too much tension when closing the fascia since reapproximation, not strangulation, is the goal. Difficulty with hemostasis is usually not a major issue. Meta-analyses of randomized trials of closure of **midline** abdominal fascial incisions show that the optimal technique for closure of these incisions is [84,85]:

- Use of a simple running technique
- Use of #1 or #2 delayed absorbable monofilament suture (eg, polydioxanone [PDS])
- Use of mass closure to incorporate all layers of the abdominal wall (except skin)
- Taking wide tissue bites (≥1 cm)
- Use of a short stitch interval (≤1 cm)
- Use of a suture length to wound length ratio of 4 to 1
- Use of non-strangulating tension on the suture

However, the majority of fascial closures after cesarean delivery involve a **transverse** fascial incision and no randomized trials have evaluated the optimum closure technique in this setting. For transverse fascial incisions, a continuous closure with slowly absorbable #1 braided suture is a common approach among general surgeons [86]. Obstetricians also commonly use this technique with #0 or #1 braided suture (eg, polygalactin 910). Polydioxanone has also been used successfully for closure of transverse fascial incisions [87]. A randomized trial of closure techniques for repair of transversely incised abdominal fascia in rabbits found that interrupted closure had a greater maximum tensile strength than continuous closure during the first two postoperative weeks, but both repair methods had similar maximum tensile strength at four postoperative weeks [88].

(See "Principles of abdominal wall closure", section on 'Fascia' and "Abdominal surgical incisions: Prevention and treatment of complications", section on 'Prevention'.)

Subcutaneous tissue — The value of irrigation before closure of the subcutaneous tissues has not been studied in a randomized trial, and is probably unnecessary in the setting of routine intravenous antibiotic prophylaxis.

We close the subcutaneous adipose layer with interrupted delayed-absorbable sutures if the layer is ≥2 cm [89,90]. The value of this approach was illustrated in a meta-analysis of randomized trials that showed suture closure of the subcutaneous adipose layer at cesarean delivery decreased the risk of subsequent wound disruption by one-third in women with subcutaneous tissue depth ≥2 cm, but not in those <2 cm [90]. Closure of the dead space seems to inhibit accumulation of serum and blood, which can lead to a wound seroma and subsequent wound breakdown [90,91]. This occurrence is a major cause of morbidity, can be costly, and lengthens the recovery time.

Use of drains — Randomized trials and meta-analyses have shown that routine use of wound drains is not beneficial [92,93], even in obese women [94]. Compared to no drain, routine use of drains does not reduce the odds of seroma, hematoma, infection, or wound disruption. Additionally, restricted use of subrectus sheath drains offers no benefit in maternal infectious morbidity compared with liberal use [58].

Skin — Reapproximation of the skin may be performed with staples or subcuticular suture; available data from randomized trials do not allow a strong recommendation for one method over the other [95]. Meta-analyses have found that staples take less time to place than subcuticular sutures and shorten operating time by about five minutes, but are associated with a doubling of wound complications (infection, separation:13 versus 6 percent) [96,97]. However, the increased risk of wound separation may have been due to removing staples too early (day 3), rather than an effect of the staples themselves [95]. (See "Cesarean delivery: Postoperative issues", section on 'Postoperative care'.)

The effect on postoperative pain is unclear: one randomized trial reported that the subcuticular closure resulted in less postoperative discomfort six weeks postoperatively than the stapled closure [98], while another found that staples resulted in less postoperative discomfort [99]. Other randomized trials found that use of staples or subcuticular sutures (absorbable or nonabsorbable monofilament, absorbable multifilament) for skin closure resulted in a similar cosmetic appearance when the scar was assessed six months postpartum [100] and similar patient satisfaction in the absence of wound complications [101].

ALTERNATIVE TECHNIQUES — Several techniques to simplify the surgical approach, decrease operating time, and reduce postoperative morbidity have been proposed. The Pelosi [9] and modified Joel-Cohen/Misgav-Ladach (table 1) [4,5] procedures have incorporated many of these modifications.

Meta-analyses of randomized trials have found the Joel-Cohen type incision has significant advantages compared to the Pfannenstiel incision, including lower rates of fever, pain, and use of analgesia; less blood loss; and shorter operating time (overall and incision-to-delivery) and hospital stay [102,103]. For example, compared to the Pfannenstiel incision, the modified Joel-Cohen/Misgav-Ladach decreased incision to delivery time by 2 to 6 minutes, blood loss by 37 to 92 mL, and total operating time by 12 to 25 minutes [103]. In addition, a randomized trial observed that the Joel-Cohen technique was associated with fewer patients with intraperitoneal adhesions at repeat cesarean delivery (11 percent versus 36 percent after standard Pfannenstiel-Kerr approach) [104].

The Pelosi technique is illustrated in the following pictures (picture 1A-C, 1C-D). There are no randomized trials comparing the Pelosi to other techniques.

However, it is impossible to assess which technical aspects of a particular method of cesarean delivery are advantageous when several aspects are studied at the same time [105]. Long-term outcomes also have not been adequately evaluated.

INCIDENTAL PROCEDURES — The most common incidental procedure at cesarean delivery is tubal sterilization. (See "Surgical sterilization of women".)

Major uterine surgery should be avoided due to the potential for severe blood loss. Myomectomy is generally contraindicated for this reason, although a few small case series have described successful excision in selected women [106,107]. Pedunculated myomas can usually be removed safely and without excessive blood loss. (See "Pregnancy in women with uterine leiomyomas (fibroids)".)

The adnexae are examined for solid and cystic masses. An ovarian cyst or mass identified incidentally at the time of cesarean delivery should be removed [108]. Complete surgical removal is preferred over aspiration and cytologic evaluation of cystic fluid since malignancy could be missed with the latter. In most cases, the patient will not have an appropriate incision for surgical staging. Therefore, gynecologic oncologists suggest a frozen section of the resected neoplasm. If it is malignant, oophorectomy can be performed and, postpartum, the patient is referred to a gynecologic oncologist for counseling, staging, and possible hysterectomy within the next one to two weeks.

A randomized trial found that elective appendectomy at the time of cesarean delivery did not increase inpatient morbidity, and increased operative time by about nine minutes [109]. The authors suggested consideration of elective appendectomy at the time of cesarean delivery in women at increased risk of having subsequent surgery to rule out appendicitis (eg, women with a palpable fecalith, abnormal appearing appendix, or history of pelvic pain or endometriosis).

INFORMATION FOR PATIENTS — UpToDate offers two types of patient education materials, "The Basics" and "Beyond the Basics." The Basics patient education pieces are written in plain language, at the 5th to 6th grade reading level, and they answer the four or five key questions a patient might have about a given condition. These articles are best for patients who want a general overview and who prefer short, easy-to-read materials. Beyond the Basics patient education pieces are longer, more sophisticated, and more detailed. These articles are written at the 10th to 12th grade reading level and are best for patients who want in-depth information and are comfortable with some medical jargon.

Here are the patient education articles that are relevant to this topic. We encourage you to print or e-mail these topics to your patients. (You can also locate patient education articles on a variety of subjects by searching on "patient info" and the keyword(s) of interest.)

- Basics topics (see "Patient information: C-section (cesarean delivery) (The Basics)")
- Beyond the Basics topics (see "Patient information: C-section (cesarean delivery) (Beyond the Basics)")

SUMMARY AND RECOMMENDATIONS

- For opening the abdomen, we suggest a transverse (eg, Pfannenstiel or Joel-Cohen) rather than a vertical skin incision (**Grade 2C**). A transverse incision is associated with less postoperative pain, greater wound strength, and better cosmetic results than the vertical midline incision. (See 'Transverse or vertical' above.)
- We do not routinely create a bladder flap. This saves time and reduces blood loss. (See 'Bladder flap' above.)
- For the hysterotomy, we suggest a transverse rather than a vertical incision for most women (**Grade 2C**). The transverse incision is associated with less blood loss, less need for bladder dissection, is easier to reapproximate, and has a lower risk of rupture in subsequent pregnancies. However, a vertical hysterotomy is indicated in some settings (eg, poorly developed lower uterine segment, lower uterine segment pathology). (See 'Hysterotomy' above.)
- We suggest blunt rather than sharp expansion of the hysterotomy incision (**Grade 2B**). Blunt expansion is quick and has less risk of inadvertent trauma to the fetus, and may reduce blood loss and extension of the incision. (See 'Hysterotomy' above.)

- We recommend spontaneous, rather than manual, extraction of the placenta (**Grade 1A**). Spontaneous extraction is associated with lower rates of endometritis and bleeding. (See 'Placental extraction' above.)
- Exteriorization or nonexteriorization of the uterus and one layer or two layer closure of the hysterotomy are all acceptable options. The choice depends on personal preference and the specific clinical setting. (See 'Exteriorizing the uterus' above.)
- For women who would consider a trial of labor after a previous cesarean delivery, we suggest a two-layer uterine closure (**Grade 2C**). (See 'Single versus double layer closure' above.)
- We suggest not closing the visceral or parietal peritoneum (**Grade 2B**). Peritoneal closure prolongs operative time, but may decrease adhesion formation. (See 'Peritoneum' above.)
- For women with subcutaneous tissue depth ≥2 cm, we recommend closure of the subcutaneous tissue layer with sutures (**Grade 1A**). Closure decreases the risk of subsequent wound disruption. (See 'Subcutaneous tissue' above.)

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