Guidelines for intraoperative care in cesarean delivery: Enhanced Recovery After Surgery Society Recommendations (Part 2)

Aaron B. Caughey, MD, PhD; Stephen L. Wood, MD; George A. Macones, MD; Ian J. Wrench, MB ChB, PhD; Jeffrey Huang, MD; Mikael Norman, MD, PhD; Karin Pettersson, MD, PhD; William J. Fawcett, MBBS, FRCA, FFPMRCA; Medhat M. Shalabi, MD; Amy Metcalfe, PhD; Leah Gramlich, MD; Gregg Nelson, MD, PhD; R. Douglas Wilson, MD, MSc

The Enhanced Recovery After Surgery Society guideline for intraoperative care in cesarean delivery will provide best practice, evidenced-based, recommendations for intraoperative care, with primarily a maternal focus. The "focused" pathway process for scheduled and unscheduled cesarean delivery for this Enhanced Recovery After Surgery cesarean delivery guideline will consider procedure from the decision to operate (starting with the 30—60 minutes before skin incision) through the surgery. The literature search (1966—2017) used Embase and PubMed to search medical subject headings including "cesarean section," "cesarean section," "cesarean section delivery," and all pre- and intraoperative Enhanced Recovery After Surgery items. Study selection allowed titles and abstracts to be screened by individual reviewers to identify potentially relevant articles. Metaanalyses, systematic reviews, randomized controlled studies, nonrandomized controlled studies, reviews, and case series were considered for each individual topic. Quality assessment and data analyses evaluated the quality of evidence and recommendations were evaluated according to the Grading of Recommendations, Assessment, Development and Evaluation system as used and described in previous Enhanced Recovery After Surgery Society guidelines. The Enhanced Recovery After Surgery cesarean delivery guideline/pathway has created a maternal focused pathway (for scheduled and unscheduled surgery starting from 30—60 minutes before skin incision to maternal discharge) with Enhanced Recovery After Surgery—directed preoperative elements, intraoperative elements, and postoperative elements. Specifics of the intraoperative care included the use of prophylactic antibiotics before the cesarean delivery, appropriate patient warming intraoperatively, blunt expansion of the transverse uterine hysterotomy, skin closure with subcuticular sutures, and delayed cord clamping. A number of specific elements of intraoperative care of women who undergo cesarean delivery are recommended based on the evidence. The Enhanced Recovery After Surgery Society guideline for intraoperative care in cesarean delivery will provide best practice, evidenced-based, recommendations for intraoperative care with primarily a maternal focus. When the cesarean delivery pathway (elements/processes) is studied, implemented, audited, evaluated, and optimized by maternity care teams, this will create an opportunity for the focused and optimized areas of care and recommendations to be further enhanced.

Key words: cesarean delivery, enhanced recovery

Enhanced Recovery After Surgery (ERAS) is a standardized, perioperative care program that now is embedded firmly within multiple surgical disciplines that include colorectal, urologic, gynecologic, and hepatobiliary surgery.[1] ERAS has been shown to result in both clinical benefits (reductions in length of stay, complications, and readmissions) and health system benefits (reduction in cost).[1,2]

From the Department of Obstetrics & Gynecology, Oregon Health & Science University, Portland, OR (Dr Caughey); the Department of Obstetrics & Gynecology, Cumming School of Medicine, University of Calgary, Calgary, Alberta, Canada (Drs Wood, Metcalfe, Nelson, and Wilson); the Department of Obstetrics & Gynecology, Washington University in St Louis, St. Louis, MO (Dr Macones); the Sheffield Teaching Hospitals Trust, Royal Hallamshire Hospital, Glossop Road, Sheffield, United Kingdom (Dr Wrench); the University of Central Florida, Orlando, FL (Dr Huang); the Divisions of Pediatrics (Dr Norman) and Obstetrics (Dr Pettersson), Department of Clinical Science, Intervention and Technology, Karolinska Institutet, Stockholm, Sweden; the Department of Anaesthesia, Royal Surrey County Hospital, Egerton Road, Guildford, United Kingdom (Mr Fawcett); the Departments of Anesthesiology and Intensive Care, Alzahra Hospital, Dubai, United Arab Emirates (Dr Shalabi); the Department of Medicine, University of Alberta, Edmonton, Alberta, Canada (Dr Gramlich).

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Corresponding author: R. Douglas Wilson, MD, MSc. doug.wilson@ahs.ca

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The intent is for this ERAS Society guideline for perioperative care in cesarean delivery to provide best practice recommendations for preoperative, intraoperative, and postoperative phases primarily. Although certain ERAS principles have been established for other abdominal/pelvic surgeries, this present ERAS cesarean delivery (ERAS CD) pathway will provide evidence-based recommendations for the surgical pathway related to cesarean delivery with primarily a maternal focus. The current document is the second in a series of 3 to focus on ERAS CD and is focused primarily on intraoperative care beginning 30—60 minutes before the procedure, with the first document focused on preoperative care and the third document focused on postoperative care. The

AJOG at a Glance

Why was this study conducted?

This Enhanced Recovery After Surgery Society guideline was created to support the most common surgical procedure in the industrialized healthcare world: the cesarean delivery. It has the goal to enhance the quality and safety of the cesarean delivery for improved maternal and fetal/neonatal outcomes through evaluation and audit.

Key findings

The broad Enhanced Recovery After Surgery Society cesarean delivery elements and recommendations (parts 1−3) break down the surgical delivery process into a "focused" pathway that starts at 30−60 minutes before skin incision, for both scheduled and unscheduled cesarean deliveries, until hospital discharge along with a longer "optimized" pathway that manages antenatal education, maternal comorbidities, and immediate neonatal needs at delivery. The intraoperative section (Part 2) focuses on the time immediately prior to beginning the surgery including prophylactic antibiotics, through the cesarean surgery, to the immediate newborn care.

What does this add to what is known?

This Enhanced Recovery After Surgery Society cesarean delivery guideline has taken the evidence-based knowledge created from the cesarean delivery research and has critically and with consensus published the information in a 3-part guideline that uses the Enhanced Recovery After Surgery Society principles and process for improved surgical quality and safety for obstetric surgical deliveries.

"focused" pathway process for scheduled and unscheduled ERAS CD has been created for this ERAS CD guideline from "decision to operate (30 - 60 minutes before skin incision) to hospital discharge."

Ultimately, ERAS is a tool for process management that creates a focused care process. The tool should be used in a cycle of audit and feedback, whereby clinicians are provided with comparative data to educate, change, and decrease the "harmful" clinical variances that are identified in certain high-volume clinical care processes and procedures that will increase quality of care, patient safety, and health outcomes.

Methods

Literature search

The author group was selected by the ERAS Society in May 2017 based on expertise in the area, and a consensus topic list was determined. The ERAS Gynecologic/Oncology guidelines[3,4] were used as templates; however, several other elements unique to cesarean section delivery were added. After the topics were agreed on, they were then allocated among the group according to expertise. The literature search (1966−2017) used Embase and PubMed to search medical subject headings including "cesarean section", "cesarean delivery", "cesarean section delivery" and all intraoperative ERAS items (Table 1). Reference lists of all eligible articles were crosschecked for other relevant studies.

Study selection

Titles and abstracts were screened by individual reviewers to identify potentially relevant articles. Meta-analyses, systematic reviews, randomized controlled studies, nonrandomized controlled studies, reviews, and case series were considered for each individual topic.

Quality assessment and data analyses

The quality of evidence and recommendations were evaluated according to the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) system[5] as used and described in previous ERAS Guidelines.[3,4] Briefly, recommendations are given as follows: Strong recommendations indicate that the panel is confident that the desirable effects of adherence to a recommendation outweigh the undesirable effects. Weak recommendations indicate that the desirable effects of adherence to a recommendation probably outweigh the undesirable effects, but the panel is less confident (Table 2). Recommendations are based on the quality of evidence: high, moderate, low, and very low, but also on the balance between desirable and undesirable effects. In some cases, strong recommendations may be reached from low-quality data and vice versa. The core ERAS CD team (A.B.C., G.A.M., S.L.W., G.N., and R.D.W.) reviewed the evidence in detail for each section and assigned both the recommendation and evidence level. Discrepancies were resolved by the lead author (A.B.C.) and senior author (R.D.W.).

Results

The cesarean delivery pathway and elements have a wide scope for maternal antenatal, delivery, and postoperative natal care. The focus of this document is on a focused pathway that starts 30−60 minutes before cesarean incision to maternal (fetal) discharge, which allows for a more consistent and generalizable ERAS CD process that includes the same comprehensive care to both unscheduled and scheduled cesarean delivery.

Intraoperative cesarean delivery pathway (focused elements)

Preoperative antimicrobial prophylaxis and skin preparation (focused element)

A cesarean delivery performed before rupture of the membranes and without chorioamnionitis usually will be considered a clean (class I) incision. However, a cesarean delivery in the setting of ruptured membranes, particularly in active phase of labor or second stage of labor or with chorioamnionitis, usually is classified as a clean contaminated (class II) incision. There could be an argument made that, at least, some of these latter incisions are contaminated (class III) incisions. Regardless, all are at

TABLE 1
Guidelines for intraoperative care in cesarean delivery: Enhanced Recovery After Surgery Society recommendations

Item	Recommendation	Evidence level	Recommendation grade
Intraoperative pathway focused: preoperative antimicrobial prophylaxis and skin preparation (focused elements)	1. Intravenous antibiotics should be administered routinely within 60 min before the cesarean delivery skin incision. In all women, a first-generation cephalosporin is recommended; in women in labor or with ruptured membranes, the addition of azithromycin confers additional reduction in postoperative infections.	High	Strong
	2. Chlorhexidine-alcohol is preferred to aqueous povidone-iodine solution for abdominal skin cleansing before cesarean delivery.	Low	Strong
	3. Vaginal preparation with povidine-iodine solution should be considered for the reduction of postcesarean infections.	Moderate	Weak
Intraoperative pathway focused			
Pre- and intraoperative anesthetic management (focused element)	1. Regional anesthesia is the preferred method of anesthesia for cesarean delivery as part of an enhanced recovery protocol.	Low	Strong
Prevention of intraoperative hypothermia (focused element)	1. Appropriate patient monitoring is needed to apply warming devices and avoid hypothermia.	Low	Strong
	2. Forced air warming, intravenous fluid warming, and increasing operating room temperature are all recommended to prevent hypothermia during cesarean delivery.	High	Strong
Cesarean delivery surgical techniques/ considerations (focused element)	1. Blunt expansion of a transverse uterine hysterotomy at time of cesarean delivery is recommended to reduce surgical blood loss.	Moderate	Weak
	2. Closure of the hysterotomy in 2 layers may be associated with a lower rate of uterine rupture.	Low	Weak
	3. The peritoneum does not need to be closed because closure is not associated with improved outcomes and increases operative times.	Low	Weak
	4. In women with $\geq$2 cm of subcutaneous tissue, reapproximation of that tissue layer should be performed.	Moderate	Weak
	5. The skin closure should be closed with subcuticular suture in most cases, because of evidence of reduced wound separation in those women whose staples were removed $\leq$4 days postoperatively.	Moderate	Weak
Perioperative fluid management (focused element)	1. Perioperative and intraoperative euvolemia are important factors in patient perioperative care and appear to lead to improved maternal and neonatal outcomes after cesarean delivery.	Low-moderate	Strong

Caughey. Guidelines for intraoperative care in cesarean delivery. Am J Obstet Gynecol 2018. *(continued)*

an increased risk of postoperative infection and have demonstrated benefit from prophylactic antibiotics and other interventions. Although the class I incisions will be predominantly at-risk from abdominal skin flora, the class II or class III incisions both carry the risk of skin flora plus the risk of exposure from vaginal flora. These microbial risks are the primary issues when considering prophylactic antibiotics, wound preparation, and vaginal preparation.

For cesarean delivery performed before rupture of the membranes, the standard of care has been to use a relatively narrow-spectrum first-generation cephalosporin directed against skin flora for infectious prophylaxis, although similar benefits have been seen with other antibiotic regimens.[6] Historically, because of concerns of fetal exposure, these antibiotics were often given after cord clamping. However, because of the benefit of a decrease in subsequent wound infections reported in several studies, it is now recommended to give the antibiotics 30–60 minutes before the

TABLE 1
Guidelines for intraoperative care in cesarean delivery: Enhanced Recovery After Surgery Society recommendations *(continued)*

Item	Recommendation	Evidence level	Recommendation grade
Neonate pathway focused: Immediate care of the newborn infant at delivery (focused element)	1. Delayed cord clamping for at least 1 minute at a term delivery is recommended.	Moderate	Strong
	2. Delayed cord clamping for at least 30 seconds at a preterm delivery is recommended.	Low-moderate	Strong
	3. Body temperature should be measured and maintained between 36.5°C and 37.5°C after birth through admission and stabilization.	Low-moderate	Strong
	4. Routine suctioning of the airway or gastric aspiration should be avoided and used only for symptoms of an obstructive airway (by secretions or meconium).	Low	Strong
	5. Routine neonatal supplementation with room air is recommended because the use of inspired air with oxygen may be associated with harm.	Low-moderate	Strong
	6. In all settings that perform cesarean delivery, a capacity for immediate neonatal resuscitation is mandatory.	High	Strong

Caughey. Guidelines for intraoperative care in cesarean delivery. Am J Obstet Gynecol 2018.

cesarean delivery when possible.[7,8] The most recent Cochrane review reported a significant reduction in composite maternal infectious morbidity for women who received preoperative prophylactic antibiotics as compared with women who received prophylactic antibiotics at the time of cord clamping (risk ratio, 0.57; 95% confidence interval, 0.45−0.72).[9] There is increasing evidence that broadening the preincision antibiotic spectrum might further reduce the risk of wound infections.[10] In a recent, multicenter trial, the addition of azithromycin to the routine cephalosporins further reduced infectious complications from 12.0% to 6.1% ($P<.001$) and wound infections from 6.6−2.4%.[11] Additionally, there have been studies of the use of antibiotic-infused drapes without adequate evidence to support routine use.[12]

There are special concerns for obese women because of their increased risk of wound complications and the potential of higher blood volume for the antibiotic distribution. In several recent studies, it has been suggested that the tissue concentrations of first-generation cephalosporins may not be adequate from the standard 1- or 2-g dosing.[13,14] However, in 2 recent prospective, randomized trials, there were no differences in infectious morbidity between 2-g and 3-g dosing of cephazolin.[15,16] Thus, further evidence must be collected before increased dosing of prophylactic antibiotics in obese women is routinely recommended.

Another recent approach to antibiotic prophylaxis in obese women has been postsurgical prophylaxis. In a recent prospective, randomized trial, the risk of surgical site infection was reduced from 15.4−6.4% ($P=.01$) from the use of cephalosporin and metronidazole versus placebo after cesarean delivery.[17] However, this prophylaxis regimen has not been compared with a preincision protocol that incorporates azithromycin and requires further study.

Wound preparation

Even before the hospital admission for a scheduled cesarean delivery, it is recommended that women shower with an antimicrobial soap if possible.[18] The Centers for Disease Control recommendations encourage the use of the chlorhexidine-alcohol scrub over the povidone-iodine solution to prepare the abdomen before surgery. Although there is a wider body of literature in other surgeries, the evidence is more scant in the setting of cesarean deliveries[19]: the 2014 Cochrane review did not demonstrate a difference.[12] However, there have been 2 large studies since that systematic review. One large study demonstrated a lower rate of wound infections with the chlorhexidine-alcohol scrub.[20] However, another recent large, randomized trial demonstrated no difference.[21] Thus, although the chlorhexidine-alcohol usually is recommended, it is based not only on the studies in cesarean deliveries but also on the wider body of evidence in other surgeries.[22]

Vaginal preparation

There is an increasing body of evidence to suggest that an antimicrobial vaginal preparation with a povidone-iodine solution before cesarean delivery in women in labor or with rupture of membranes reduces the risk of infectious complications. In the most recent Cochrane review, the risk of endometritis was reduced from 8.3−4.3% (relative risk, 0. 45; 95% confidence interval, 0.25−0.81).[23] In stratified analyses, this was true for women both in labor and with ruptured membranes.

TABLE 2
Grading of Recommendations, Assessment, Development and Evaluation system for rating quality of evidence and strength of recommendations

Grading of Recommendations, Assessment, Development and Evaluation	Definition
Rating quality of evidence[5]: evidence level	
High quality	Further research is unlikely to change confidence in estimate of effect.
Moderate quality	Further research is likely to have important impact on confidence in estimate of effect and may change the estimate.
Low quality	Further research is very likely to have important impact on confidence in estimate of effect and likely to change the estimate.
Very low quality	Any estimate of effect is very uncertain.
Rating strength of recommendations[5]: recommendation strength	
Strong	When desirable effects of intervention clearly outweigh, or are outweighed by, the undesirable effects.
Weak	When trade-offs are less certain, either because of low-quality evidence or because evidence suggests desirable and undesirable effects are closely balanced.

Caughey. Guidelines for intraoperative care in cesarean delivery. Am J Obstet Gynecol 2018.

Summary and recommendation.

1. Intravenous antibiotics should be administered routinely within 60 minutes before the cesarean delivery skin incision. In all women, a first-generation cephalosporin is recommended; in women in labor or with ruptured membranes, the addition of azithromycin confers additional reduction in postoperative infections (evidence level: high/recommendation grade: strong).
2. Chlorhexidine-alcohol is preferred to aqueous povidone-iodine solution for abdominal skin cleansing before cesarean delivery (evidence level: low/recommendation grade: strong).
3. Vaginal preparation with povidone-iodine solution should be considered for the reduction of infections after cesarean delivery (evidence level: moderate/recommendation grade: weak).

Intraoperative cesarean delivery pathway (focused elements)

Pre- and intraoperative anesthetic management (focused element)

Regional anesthesia has been found to have a positive impact for enhanced recovery outcomes in terms of pain control, organ function, mobility, postoperative nausea and vomiting, number of days spent in hospital, and adverse events.[24] Obstetric anesthesia regional techniques are thought to be safer than general anesthesia and their increased adoption is thought to be 1 of the reasons that maternal death rates because of anesthesia have fallen.[25] However, a meta-analysis of mode of anesthesia for cesarean delivery[26] reported that, other than a higher maternal blood loss with general anesthesia, there was no evidence that regional anesthesia was superior to general anesthesia in terms of major maternal or neonatal outcomes. This may be due to the infrequency of death and serious morbidity that leads to the inadequate power of most studies. Additionally, because of a greater potential for postoperative sedation with general anesthesia, regional anesthesia may be the preferable choice in this regard.[27–29]

Outcomes are similar for spinal and epidural anesthesia[30]; the onset time for an effective block is shorter and the incidence of intraoperative pain is lower for spinal than for epidural anesthesia.[31] Combined spinal epidural anesthesia may allow for a more rapid motor recovery than spinal anesthesia,[32] although the presence of an epidural catheter provides a capability to extend or prolong an inadequate spinal block.[33] The use of intrathecal morphine results in improved postoperative analgesia,[34,35] although the risk of side-effects (nausea, vomiting, and pruritis) increases with the dosage used and the optimal dose is not established. Shorter acting opioids such as fentanyl and sufentanil, when administered intrathecally, improve the intraoperative but not the postoperative analgesia.[34] In the absence of intrathecal morphine, the transversus abdominis plane field block provides superior analgesia when compared with a placebo and can reduce the first 24-hour maternal morphine consumption in the setting of a multimodal analgesic regimen.[36] A Cochrane review of local analgesia infiltration and abdominal nerve blocks found that these infiltrative techniques improved postoperative analgesia for caesarean delivery.[37]

Summary and recommendation. Regional anesthesia is the preferred method of anesthesia for caesarean delivery as part of an enhanced recovery protocol (evidence level: low/recommendation grade: strong).

Prevention of intraoperative hypothermia (focused element)

Perioperative hypothermia can occur in 50–80% of patients who undergo spinal

anesthesia for cesarean delivery.[38,39] Several randomized control studies showed that perioperative hypothermia is associated with complications in nonpregnant patients.[40,41] These complications have included surgical site infection, myocardial ischemia, altered drug metabolism, coagulopathy, prolonged duration of hospitalization, shivering, reduced skin integrity, and poor patient satisfaction.[42−44] Hypothermia can also have adverse effects on neonates, such as temperature, umbilical pH, Apgar score.[45,46]

Generally, patient core temperature is monitored poorly during neuraxial anesthesia.[47,48] Skin temperature monitoring can be used during neuraxial anesthesia, but the temperatures are 2.0−4.0°C less than the core temperature.[49] Axillary temperatures can be measured if the sensor is placed over the axillary artery with arms adducted to the side.[50] Thus, it is important to consider how to best monitor a patient's temperature during surgery.

A recent systematic review (13 randomized controlled studies and 789 patients) examined the efficacy of active warming during cesarean delivery.[51] The active warming methods included forced air warming and intravenous fluid warming. Active warming group (either forced air warming or intravenous fluid warming) patients had significantly less temperature change ($P=.0002$), fewer shivering episodes ($P=.0004$), higher temperature at end of surgery or on arrival to the postanesthetic care unit ($P<.00001$), and higher umbilical artery pH ($P=.04$). A randomized controlled study showed fluid warming combined with forced air warming to be effective in decreasing the incidence of perioperative hypothermia and improving maternal thermal comfort.[52]

Ambient operating room temperature can affect maternal and neonatal temperature. A randomized controlled trial with 799 patients demonstrated that operating room temperature at 23.0°C resulted in significantly lower maternal hypothermia when compared with the operating room temperature at 20.0°C.[53]

Summary and recommendation.

1. Appropriate patient temperature monitoring is needed to apply warming devices and avoid hypothermia (evidence level: low/recommendation grade: strong).
2. Forced air warming, intravenous fluid warming, and increasing operating room temperature are all recommended to prevent hypothermia during cesarean delivery (evidence level: moderate/recommendation grade: strong).

Cesarean delivery surgical techniques/considerations (focused element)

In the last decades, cesarean delivery rates have increased in many countries and have become the most commonly performed intraperitoneal surgical procedure. Despite its worldwide spread, a consensus on the most appropriate cesarean delivery technique to use has not yet been reached.[54] The operative technique performed generally is based on the individual experience and preference of operators, the characteristics of patients, and the timing and urgency of the intervention. However, there are many randomized trials that have examined a variety of the approaches to various components of the cesarean delivery; in 1 recent study when a range of evidence-based approaches were adopted, cesarean delivery wound complications were reduced.[55]

Surgical incision

The traditional approach to the cesarean delivery has been the Pfannenstiel skin incision that is made sharply through the subcutaneous tissue, sharply through the fascia, and sharply entering the parietal peritoneum. The Kerr hysterotomy is also made sharply in a transverse fashion into the uterus. A bladder flap commonly was created to dissect the bladder inferiorly away from the hysterotomy, although a recent metaanalysis does not support this being performed routinely.[56]

More recently, the Joel-Cohen incision has been described. The subcutaneous tissue is left undisturbed apart from the midline, and the abdominal fascia is incised only at the midline in a transvers fashion. The rectus sheath is separated along its fibers with blunt dissection, and the 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 small transverse incision is made into the uterus with a scalpel, 2 cm above the vesical-uterine fold until the membranes bulge, and 2 index fingers are inserted to stretch the opening laterally. A modification to this of cranial-caudal expansion has been described and is associated with fewer extensions and less blood loss.[57,58] Overall, the Joel-Cohen approach has been associated with lower operative times and lower blood loss.[59]

Repair of incision

The uterine incision is repaired commonly in 1 or 2 layers with a continuous unlocked suture.[60−62] Generally, a 2-layer closure has been used because of nonrandomized trial evidence that suggests a higher rate of uterine rupture in women who had pregnancies after a previous cesarean delivery with hysterotomies closed in a single layer. However, the most recent Cochrane review did not find a difference in outcomes between 1- or 2-layer closure.[58] The use of a delayed absorbable monofilament (Monocryl; Ethicon Inc, Bridgewater, NJ) has been described, as has chromic catgut and Vicryl (Ethicon Inc), without strong evidence to support a particular suture. There are studies of blunt vs sharp needles that do not demonstrate benefit to patients.[63] In such studies, a reduction in glove perforations is seen (relative risk, 0.54; 95% confidence interval, 0.41−0.71), but providers are less satisfied with blunt needles.[64]

Historically, the visceral and parietal peritoneum were closed; however, in systematic reviews, there is no evidence that outcomes such as intraabdominal adhesions are different and that the operative times are shorter leaving the peritoneum open.[56,65] Similarly, the rectus muscles commonly were sutured at the midline, but there is no evidence to support closure, and there is concern that

intramuscular sutures will tear through.[66] The abdominal fascia is usually closed with a continuous suture, PDS or Vicryl.[67]

The subcutaneous tissue, when it is <2 cm in thickness is often not reapproximated. However, in women whose subcutaneous tissue is ≥2 cm in thickness, reapproximation with catgut or Vicryl suture has been demonstrated to reduce wound complications.[68] Placement of a subcutaneous drain even with wounds >4 cm in thickness has not been demonstrated to improve outcomes and has been associated with worse wound outcomes.

The skin can be closed with staples or subcuticular/intracutaneous techniques with Vicryl or Monocryl. The most recent Cochrane metaanalysis found no difference between the 2 approaches with regards to wound infections or complications overall.[69] However, there was a large trial published in 2014 that demonstrated a significant reduction in wound complications[70]; in a subsequent metaanalysis of skin closure that incorporated this trial, subcuticular closure with suture was supported for the reduction in wound complications.[71] Additionally, women also have improved preference and experience scores with suture closure.[72] One caveat is that the only difference is in wound separation; in many trials, staples were removed <4 days after surgery. Similarly, in a recent trial of obese women only, although there were no clinical differences, more women would choose suture for a future surgery.[73]

Once the wound is closed, there is increasing evidence that prophylactic negative-pressure wound therapy may be useful, particularly in obese women. In a recent systematic review, there was evidence of reduction in wound infections (relative risk, 0.45; 95% confidence interval, 0.31−0.66) and overall wound complications (relative risk, 0.68; 95% confidence interval, 0.49−0.94) in high-risk women (predominantly obese) who were assigned randomly to receive the negative-pressure dressing.[74] There are several ongoing trials at this time; thus, although it would be reasonable for a clinician to use this technology, there is a need for additional research to fully address this question.

Summary and recommendation.

1. Blunt expansion of a transverse uterine hysterotomy at time of cesarean delivery is recommended to reduce surgical blood loss (evidence level: moderate/recommendation grade: weak).
2. Closure of the hysterotomy in 2 layers may be associated with a lower rate of uterine rupture (evidence level: low/recommendation grade: weak).
3. The peritoneum does not need to be closed because closure is not associated with improved outcomes and increases operative times (evidence level: low / recommendation grade: weak).
4. In women with ≥2 cm of subcutaneous tissue, reapproximation of that tissue layer should be performed (evidence level: moderate/recommendation grade: weak).
5. The skin closure should be closed with subcuticular suture in most cases, because of evidence of reduced wound separation in those whose staples were removed ≤4 days after surgery (evidence level: moderate/recommendation grade: weak).

Perioperative fluid management (focused element)

Perioperative euvolemia is an important factor to obtain optimal outcomes after cesarean delivery. Intravascular volume determines not only blood pressure but also cardiac output and oxygen delivery. Maintaining adequate uterine perfusion cannot only optimize fetal oxygenation and prevent acidosis but also deliver nutrients and eliminate waste products from the uterine myometrium.[75] Perioperative fluid overload has higher risks of increased cardiovascular work and pulmonary edema in pregnant women.[76] Maternal intrapartum fluid overload can result in newborn infant weight loss during the first 3 days after birth.[77,78]

The incidence of hypotension, after spinal anesthesia, is high and can cause severe effects on the mother and fetus.[79] Studies show that a combination of vasopressors and adequate fluid therapy could be effective in reducing the incidence and severity of hypotension during spinal anesthesia for cesarean delivery.[80,81] Perioperative fluid management is always a controversial topic in anesthesia practice. Adequate perioperative fluid administration can reduce surgical morbidities.[82] Although the use of intravenous fluids to preload the circulation is recommended, a recent consensus statement and accompanying editorial suggest that intravenous fluids alone have limited efficacy and that many clinicians now administer prophylactic phenylephrine infusions, which not only prevent hypertension but also reduce the risk of fetal acidosis.[83,84] One metaanalysis and systematic review showed that the use of goal-directed fluid therapy in patients who underwent major surgery reduced postoperative complications such as wound infection, abdominal complications, and hypotension.[85] Another metaanalysis and systematic review indicated that goal-directed fluid therapy significantly reduced the incidence of surgical site infections and length of hospital stay after abdominal surgery.[86] However, the number of high-quality research trials that have evaluated the effects of goal-directed fluid therapy during cesarean delivery is too few to provide consistent evidence of benefit.

More complex areas include patients with cardiovascular disease, such as severe preeclampsia and preexisting cardiac disease. These patients should have multidisciplinary preoperative assessment and planning and may require invasive blood pressure monitoring and cardiac output measurements to optimize both fluid management and the use of vasoactive drugs or inotropes. These patients require vigilance not only before delivery of the fetus but also with the cardiovascular changes that may occur after the use of uterotonics and uterine contraction after delivery.

Summary and recommendation. Preoperative and intraoperative euvolemia are important factors in patient perioperative care and appear to lead to improved maternal and neonatal outcomes after cesarean delivery (evidence level: low to moderate/recommendation grade: strong).

Neonate pathway (focused element)

Immediate care of the newborn infant (optimized element)

The stress of being born exceeds that of most other critical life-events, and there are significant transitions in physiology to accomplish. To promote a safe and successful transition from fetal to neonatal life, the immediate care of the newborn infant is important.

In all settings that perform cesarean delivery, fitness for service includes a capacity (equipment, staffing, and skills) and preparedness for immediate neonatal resuscitation if needed.[87] Apgar scores are important health and performance indicators and should be assessed and documented at 1, 5, and 10 minutes after delivery. For the vigorous infant, interventions in the operating room include optimal timing of umbilical cord clamping, hypothermia prevention, facilitating onset of breathing, and maternal-neonatal skin-to-skin contact.

Delay of clamping of the umbilical cord for at least 1 minute after term delivery decreases anemia in infancy and improves neurodevelopmental outcomes.[88–91] In cesarean delivery, the newborn infant can be placed on the maternal abdomen or legs or held by the surgeon or assistant close to the level of the placenta until the umbilical cord is clamped.[92] In preterm infants, delayed cord clamping for at least 30 seconds has been reported in systematic reviews to contribute to less need for transfusion, less intraventricular hemorrhage, and lower risk for necrotizing enterocolitis than after immediate cord clamping.[93–97] These findings have been challenged by a large and recent randomized controlled trial.[98] Because delayed cord clamping is associated with increased risk for hyperbilirubinemia, care providers should ensure they can monitor for and treat neonatal jaundice.[88–91] Immediate cord clamping should be restricted to infants with immediate need of resuscitation or when placental circulation is not intact.

Hypothermia is associated with increased neonatal morbidity and death across gestational ages. Standards for operating room temperature (21–25°C) may maintain both maternal and neonatal normothermia.[99] Immediate drying and covering of the infant's head reduce heat losses while awaiting cord clamping. Use of exothermic heaters or open bed incubators, transwarmer mattresses, plastic wraps/bags, and caps all keep preterm infants warmer and lead to higher temperatures on admission to neonatal units and less hypothermia.[100–103] Body temperature should be measured and maintained between 36.5°C and 37.5°C after birth through admission and stabilization.[87]

Besides hypothermia prevention, supporting the infant to regain body control and gently stimulating for first breath or cry are recommended. Approximately 85% of babies who are born at term will initiate spontaneous respirations within 10–30 seconds of birth; an additional 10% will respond during drying and stimulation, whereas the remaining 5% need some form of assisted ventilation.[87] Routine suctioning of the airway or gastric aspiration should be avoided; secretions should be cleared only if they appear to be obstructing the airway. A similar approach is recommended if meconium is present in the amniotic fluid.[87,104,105] Routine neonatal supplementation (outside resuscitation) of the inspired air with oxygen may be associated with harm and is not recommended.[106]

The care of the preterm infant (<37 weeks gestation) can be optimized, starting in the delivery room. Katheria et al[107] review the use of checklists, avoidance of early cord clamping, resuscitation during delayed cord clamping, consideration for early administration of caffeine soon after birth, and the use of additional physiologic monitoring (electrocardiogram, carbon dioxide, respiratory function (airway pressure/tidal volume) in the delivery area. A delivery room resuscitation checklist directs communication and directed care. The benefits of delayed cord clamping and, if required, cord milking for cesarean delivery were supported. The early use of caffeine is discussed; however, larger prospective trials are required that are related to intubation, intraventricular hemorrhage, and long-term outcome (chronic lung disease/neurodevelopmental outcomes). Electrocardiogram use is supported, although the other monitoring requires further evaluation.[107]

Neonatal morbidity in a planned cesarean delivery setting was compared in 2 cohorts of women, those with no labor and those with spontaneous onset of labor before the cesarean delivery.[108] Data were stratified for early term (37–38 weeks) and full term (39–40 weeks). Among 103,919 live births, there were 5071 nonlabor and 731 postlabor onset cesarean deliveries. Similar risks for neonatal admission and respiratory distress were found for the 2 groups, but a 2- to 3-fold increase for neonatal septicemia or antibiotic use at early term was identified. Labor onset at early term had decreased maternal blood loss of >500 mL after cesarean delivery but increased endometritis and antibiotic use. The conclusion was that labor onset before planned cesarean delivery was not associated with a decrease in neonatal respiratory morbidity but may be associated with increased risks of neonatal infection.

Summary and recommendations.

1. Delayed cord clamping for at least 1 minute at a term delivery is recommended (evidence level: moderate/recommendation grade: strong).
2. Delayed cord clamping for at least 30 seconds at a preterm delivery is recommended (evidence level: low-moderate/recommendation grade: strong).
3. Body temperature should be measured and maintained at between 36.5°C and 37.5°C after birth, through admission and stabilization (evidence level: low-moderate/recommendation grade: strong).
4. Routine suctioning of the airway or gastric aspiration should be avoided and used only for symptoms of an obstructive airway (by secretions or meconium; evidence level: low/recommendation grade: strong).
5. Routine neonatal supplementation with room air is recommended because the use of inspired air with oxygen is not recommended and may be associated with harm

TABLE 3
Enhanced Recovery After Surgery for cesarean delivery preoperative modifiable clinical factors

Nonmodifiable clinical factors	Modifiable clinical factors
Paternal age	
History (obstetrics/medical/surgery/body mass index)	Optimization of selected comorbidities (hypertension/diabetes mellitus/anemia/smoking; small for gestational age/large for gestational age/stillbirth/preterm birth at <34 weeks gestation)
Family history (genetics/birth defects/ multifactorial disease)	Surgical pathway (preoperative, intraoperative, postoperative)
Gestational weeks 0–20 (chromosomes/birth defects/miscarriage)	

Caughey. Guidelines for intraoperative care in cesarean delivery. Am J Obstet Gynecol 2018.

(evidence level: low-moderate/ recommendation grade: strong).

6. In all settings that perform cesarean delivery, a capacity for immediate neonatal resuscitation is mandatory (evidence level: high/recommendation grade: strong).

Comments

In North America, the most common indication for admission to the hospital is childbirth, and the most common surgery is a cesarean delivery. With this clinical volume of obstetric surgical activity, it seems appropriate that the ERAS process be applied to this surgical care arena to improve patient outcomes with the use of evidence-based approaches. Further, the impact may be even greater because there are always ≥2 patients (mother and fetus) impacted by such care.

There are quality industry-based Deming principles that can be directed toward healthcare process management such: quality improvement is the science of process management; if you cannot measure it, you cannot improve it; managed care means managing the processes of care (not the human resources of care); getting the right data in the right format at the right time in the right hands; and engaging the human healthcare resources (physicians, nurses, and other allied health professionals).[109] Of course it is important to note that some significant pregnancy-related factors can be measured but cannot be modified (Table 3).

The frequency of a cesarean delivery has increased from 4.5% in 1970 to 31.9% in 2015 in the United States. In response to this increasing surgical activity, many groups have attempted to initiate process change, but the approaches have varied and clinical care goals nationally have not been achieved in terms of reduction of morbidity and mortality rates.[110] The indications for a cesarean delivery have been summarized by the Maternal-Fetal Medicine Unit Network: primary indications (dystocia 37%; nonreassuring fetal heart rate 25%; abnormal fetal presentation 20%; other 15%; failed forceps or vacuum delivery 3%); repeat indications (no vaginal birth after cesarean section attempt 82%; failed vaginal birth after cesarean section attempt 17%; failed forceps or vacuum delivery 0.4%).[111]

Cesarean delivery has associated risk and benefit profiles for both processes of unscheduled or scheduled surgery. Complications associated with pregnancy outcomes after a scheduled low-risk cesarean delivery (46,766 patients) and planned vaginal birth (2,292,420 patients) have been reported in a large cohort study.[112] The overall maternal morbidity (cesarean delivery 2.23%; vaginal birth 0.9%) was not significant for all comparisons.[112] Other investigators have reported a 2-fold increase for cesarean delivery with an increased morbidity outcome secondary to puerperal infection, hemorrhage, and thromboembolism.[113,114]

Comparisons of multiple repeat cesarean deliveries has shown that, after the second repeat cesarean delivery, there is an increasing risk for wound and uterine hematoma (4–6%), placenta previa (1–2%), red cell transfusions (1–4%), hysterectomy (0.5–4%), and placenta accreta (0.25–3%).[115] Initiatives to reduce the frequency of cesarean delivery and enhance maternal safety have been initiated.[116] Additionally, approaches to reducing complications in cesarean delivery have been adopted and demonstrated to be impactful.[117]

The focused ERAS CD pathway has summarized a number of evidenced-based intraoperative clinical care processes. Recommendations for the scheduled/unscheduled cesarean delivery with the level of evidence and the recommendation grade are summarized in Table 2. Each of the elements or processes the focused ERAS CD pathway has the opportunity to be measured, compared between services/providers, and improved as required.

Elements to consider, for the creation of a clinical audit tool,[118] require (1) that the audited pathway has an important impact in terms of costs, resources, or risk, (2) that strong scientific evidence is available, and (3) that improvements to be made on the topic in question can be evaluated easily and become a source of important clinical/organizational consequence(s).

The purpose of quality improvement is to enhance the safety, efficiency, and effectiveness in the multiple areas of the healthcare process. Surgical healthcare has become a more delegated team sport with optimized preoperative preparation (patient education/informed consent), improved surgical process and activity

measurements of the services provided (Surgical Safety Checklist/ERAS/National Surgical Quality Improvement Program), the identification and removal of unjustified systems and human-based variability, team building practice (simulation), and the introduction of new training approaches and oversight (competency by design).

The ERAS CD guideline/pathway has created a focused pathway (for scheduled and unscheduled surgery starting from 30−60 minutes before skin incision to maternal discharge) with 5 preoperative elements (8 recommendations); 4 intraoperative elements (9 recommendations); 9 postoperative elements (11 recommendations); and 1 neonatal element (6 recommendations). This document focused specifically on the intraoperative pieces along with preoperative antibiotics and neonatal care.

As clinicians adopt these approaches, there is a need to assess outcomes continuously and to use quality improvement approaches to incorporate best practices. More prospective and quality assessment/improvement research, evaluation, audit, and collaboration will be required for the enhancement of the maternal and fetal health outcomes, quality, and safety. ■

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