Guidelines for intraoperative care in cesarean delivery: Enhanced Recovery After Surgery Society recommendations (part 2)—2025 update

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Enhanced recovery after cesarean delivery protocols include evidence-based interventions which are designed to improve patient experience and maternal and neonatal outcomes, whilst reducing healthcare related costs. This is the first update to the Enhanced Recovery After Surgery Society guidelines for intraoperative care in cesarean delivery published in 2018. Interventions were selected based on expert consensus. An updated literature search was conducted in September 2024 involving the Embase, PubMed MEDLINE, EBSCO Cumulative Index of Nursing and Allied Health Literature, Scopus, and Web of Science databases. Targeted searches were performed by a medical librarian to identify relevant articles published since the 2018 Enhanced Recovery After Surgery Society guidelines publication, which evaluated each intraoperative enhanced recovery after cesarean delivery intervention, focusing on randomized clinical trials and large observational studies (≥800 patients) to maximize search feasibility and relevance. Following a review of the evidence, consensus was achieved surrounding the quality of evidence and strength of recommendation for each proposed intervention according to the Grading of Recommendations, Assessment, Development, and Evaluation system. The ten recommended enhanced recovery after cesarean delivery intraoperative intervention categories are: (i) use of personal support persons (very low evidence, strong recommendation); (ii) prophylactic antibiotics (moderate to high evidence, strong recommendation); (iii) abdominal and vaginal preparation (moderate evidence, strong recommendation); (iv) antiemetic prophylaxis (low evidence, strong recommendation); (v) prevention of spinal hypotension (low evidence, strong recommendation); (vi) maintenance of normothermia (moderate evidence, strong recommendation); (vii) maintenance of euvolemia (low evidence, strong recommendation), (viii) optimal use of uterotonics (moderate evidence, strong recommendation); (ix) multimodal analgesia (low evidence, strong recommendation); and (x) early initiation of skin-to-skin care (moderate evidence, strong recommendation). The ten recommended intraoperative interventions outlined above represent the best evidence to date and should be considered in the absence of contraindications in patients undergoing cesarean delivery to optimize patient recovery and outcomes.

Key words: cesarean delivery, intraoperative care, protocol adherence, quality, safety

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Introduction

Enhanced recovery after cesarean delivery (ERAC) was first described in 2013 and approaches have been increasingly adopted globally.[1] The intent of ERAC is to improve both maternal and neonatal outcomes through the implementation of evidence-based interventions which are designed to reduce variability in care and improve patient experience.[2,3]

Cesarean delivery (CD) is now the most commonly performed inpatient surgery worldwide and accounts for 20% of all deliveries.[4] Therefore, the potential impact of implementing ERAC guidelines for pregnant patients is large and far-reaching. The approaches to caring for pregnant people in the operating room can improve both patient and neonatal outcomes, with attention to the immediate preparation of patients for surgery as well as intraoperative care.

The Enhanced Recovery After Surgery (ERAS) Society guidelines for intraoperative care during cesarean delivery presented in this article provide best practice recommendations for the intraoperative phase of care. A recent initiative was led by the American Society of Anesthesiologists (ASA) and included representatives from multidisciplinary professional society stakeholders across the United States (American College of Obstetricians and Gynecologists, Society of Maternal Fetal Medicine, Society of OB/GYN Hospitalists, ERAS Society, ASA, Society for Obstetric Anesthesia and Perinatology, American Association of Nurse Anesthesiology, and Association of Women's Health, Obstetric and Neonatal Nurses), and patient representatives.[5] This resulted in recommendations surrounding ten ERAC intervention categories in the intraoperative phase which forms the basis of this guideline update.

In the prior ERAS intraoperative guidelines for cesarean delivery, there were evidence reviews and discussions of surgical approaches. However, the only recommendations made that would improve recovery were that the blunt expansion of the uterine hysterotomy should be used to reduce surgical blood loss and that a subcuticular closure should be used in most cases to reduce the risk of wound separation. Both of these recommendations were weak and based on moderate evidence. Given that there was no new evidence to change these recommendations, they were not included in this updated ERAC document.

The focus of this document is to provide an up-to-date summary of the evidence supporting each of the intraoperative recommendations. This is the first update to the ERAS Society guidelines published since 2018.[6]

Methods

Guideline methodology and literature search

The guideline update proposal was approved by the ERAS Society Guideline Committee in September 2024. The author group was based on international expertise in the area, and the guideline methodology followed was endorsed by the ERAS Society, as published previously.[7] A consensus ERAS cesarean delivery intraoperative topic list was determined. After the topics were agreed on, they were allocated among the group according to expertise. The literature search (2017—September 2024) used Embase, PubMed MEDLINE, EBSCO CINAHL (Cumulative Index of Nursing and Allied Health Literature), Scopus, and Web of Science databases to search controlled vocabulary (medical subject headings) and keywords that included "Cesarean Section," "Cesarean Delivery," "Cesarean Section Delivery," and all intraoperative ERAS items, focusing on randomized clinical trials and large observational studies ($\geq$800 patients) to maximize search feasibility and relevance. Reference lists of all eligible articles were cross-checked for other relevant studies. Of note, while pregnant people can be a range of genders, the large majority identify as women, and much of the research regarding ERAC identify subjects as women. Thus, throughout, we use both nongendered and gendered language.

Quality assessment and data analyses

The quality of evidence and recommendations were evaluated according to the Grading of Recommendations, Assessment, Development, and Evaluation system,[8] as used and described in previous ERAS Guidelines (Table 1). Briefly, the following recommendations are given: strong recommendations indicate that the panel is confident that the desirable effects of adherence to a recommendation outweigh the undesirable effects; and weak recommendations indicate that the desirable effects of adherence to a recommendation probably outweigh the undesirable effects, but the panel is less confident.

Recommendations are based not only 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 (P.S., G.S.N., A.B.C., R.D.W., G.A.M.) reviewed the evidence in detail for each section and assigned both the recommendation and evidence level. Discrepancies were resolved by the lead and senior authors.

Results

Recommended intraoperative interventions following cesarean delivery are summarized in Table 2 along with the quality of evidence and strength of recommendation. A summary of the evidence supporting each recommended intervention is provided below.

Personal support persons in the operating room

What constitutes personal support for pregnant people during labor and delivery varies in the literature. Some studies focus on the patient's partner or loved ones, while others consider doulas, midwives, and other members of the healthcare team as "continuous support" for the patient during labor and delivery. When discussing personal support persons in the operating room during cesarean delivery, the sparse evidence primarily focuses on the patient's partner or loved ones.

Support persons being a benefit or a harm depends on the type and quality of the support person; the advantages of a support person during vaginal birth include psychosocial support for the pregnant person and their partner, positive reported[9] and early skin-to-skin

TABLE 1
Grading of Recommendations, Assessment, Development, and Evaluation system

Variable	Definition
Rating quality of evidence: 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: recommendation strength	
Strong	When desirable effects of intervention clearly outweigh the undesirable effects, or clearly do not.
Weak	When trade-offs are less certain: either because of low quality evidence or because evidence suggests desirable and undesirable effects are closely balanced.

contact, but the converse could also be experienced.[10,11] This adds complexity to establishing the effectiveness of support persons in labor and delivery. However, a systematic review on continuous labor support including 27 trials found a positive effect of continuous support during childbirth on length of labor, risk of progressing to cesarean delivery, and neonatal Apgar[12]

While there is evidence to advocate for the presence of a personal support person during vaginal birth, there is less evidence exploring the effectiveness of personal support persons during cesarean delivery (either scheduled or unscheduled). A scoping review of studies exploring the evidence on partner presence in the operating room during unscheduled cesareans included only 5 studies that reported quantitative data.[13–15] The full texts of 3 of these studies were not available (nor were the abstracts for 2). The majority of the studies were published in the 1980s and used observational study designs. These studies explored patient experience,[14] neonatal Apgar score,[6] time from skin incision to delivery,[13] and number of maternal transfusions.[13] A recent quasi-experimental study compared elective cesarean delivery with and without partner presence and found that partner presence decreased surgery-related anxiety.[16] Additionally, one randomized controlled trial found a modest effect of partner presence in the operating room, specifically during neuraxial analgesia placement, reducing patient anxiety.[17] Interestingly, one study explored the perceptions of anesthesiologists regarding partner presence during neuraxial analgesia placement and found anesthesiologists generally supportive of the partners' presence.[18] Collectively, the evidence suggests that there are no negative consequences of partners being present in the operating room, but the measured outcome differences were not statistically significant.

Summary

The review identified minimal, indirect evidence of very low quality exploring the use of personal support persons (partner or other) in the operating room during a cesarean delivery. Given the minimal risk of negative consequences of personal support persons being present in the operating room, and the potential for positive outcomes associated with the presence of a personal support person, it is recommended that a personal support person be present in the operating room if requested by the patient.

Recommendation: During cesarean delivery without general anesthesia, a support person should be present in the operating room if requested by the patient.

Quality of evidence: Very low.

Strength of recommendation: Strong.

Antibiotic prophylaxis

Postpartum infections are a common and preventable cause of maternal morbidity. Multiple studies continue to support administering antimicrobial prophylaxis up to 60 minutes prior to skin incision rather than after umbilical cord clamping to significantly reduce surgical site infections (SSIs), endometritis, and other postpartum infections.[19–23] Single dose antibiotic regimens remain equivalent or superior to multidose regimens in reducing peripartum infection while also ensuring appropriate antimicrobial stewardship.[24,25] Evidence continues to support the addition of azithromycin to standard preoperative antibiotics for unscheduled cesarean deliveries.[26–30] Azithromycin may be considered in scheduled deliveries in the nonobese population,[31] but further research is needed.

Patients living with obesity represent a population at increased risk of postpartum infection. There is evidence that tailored and extended antibiotic regimens may provide additional benefit. Recent randomized controlled trials (RCTs) have demonstrated that 48 hours of postoperative oral cephalexin plus metronidazole (in addition to standard preoperative prophylaxis with single dose intravenous [IV] cephalosporin) decreases SSI in patients living with obesity.[32,33] Despite studies indicating increased minimal inhibitory concentration with 3 g dosing for patients with BMI>40 kg/m^2,[34,35] only 1 cohort study has assessed clinical outcomes. That study compared 2 g vs 3 g dosing of cefazolin prior to cesarean delivery and found no difference in the incidence of SSI.[36,37] A recent RCT

TABLE 2
ERAC - a summary of intraoperative interventions with GRADE level of evidence and strength of recommendation

	Category	Recommended intraoperative intervention	Level of evidence	Strength of recommendation
1	Personal support persons in the operating room	During cesarean delivery without general anesthesia, a support person should be present in the operating room if requested by the patient.	Very low	Strong
2	Prophylactic antibiotics	First generation cephalosporins should be used for antimicrobial prophylaxis with weight-based dose adjustments and administered within 60 min prior to skin incision to prevent postpartum infections.	High	Strong
		Azithromycin should be added to the preoperative antibiotic prophylaxis regimen in patients undergoing unscheduled cesarean delivery.	High	Strong
		In patients living with obesity, antibiotic prophylaxis can include the addition of preoperative azithromycin or postoperative oral dosing of cephalexin plus metronidazole for 48 h.	Moderate	Strong
3	Abdominal and vaginal preparation	Preoperative abdominal preparation with a chlorhexidine-based preparation is recommended prior to cesarean delivery.	Moderate	Strong
		Preoperative vaginal preparation with a chlorhexidine or povidone-iodine solution is recommended for patients undergoing intrapartum cesarean delivery or with ruptured membranes, and can be considered for scheduled cesarean delivery without ruptured membranes.	Low	Strong
4	Antiemetic prophylaxis	Multitherapy (dual agent) antiemetic prophylaxis.	Low	Strong
5	Prevention and treatment of spinal-induced hypotension	Maintain maternal blood pressure with a variable rate vasopressor infusion and crystalloid coload	Moderate	Strong
		Apply left lateral tilt or other uterine displacement techniques once the pregnant person is in the supine position on the operating table	Low	Strong
6	Maintenance of normothermia	Interventions to maintain normothermia such as warmed IV fluids and forced air warming should be considered for cesarean delivery.	Moderate	Strong
7	Maintenance of euvolemia	Manage intravenous fluids to achieve euvolemia	Low	Strong
8	Optimal use of uterotonic agents	Routine administration of postdelivery oxytocin (or carbetocin) as first line agent for prophylaxis against uterine atony.	Moderate	Strong
9	Multimodal analgesia	Intrathecal morphine to improve postoperative analgesia	High	Strong
		Preoperative or intraoperative acetaminophen	Moderate	Strong
		Intraoperative NSAIDs	High	Strong
		Intraoperative dexamethasone to enhance multimodal analgesia may be considered.	Low	Weak
		Supplemental local blocks if intrathecal morphine not used	High	Strong
10	Early initiation of skin-to-skin care of neonate	Early initiation of skin-to-skin care should be implemented (birthing or nonbirthing) for breastfeeding	Moderate	Strong
		Early initiation of skin-to-skin care can facilitate a smoother postnatal adaptation	Very low	Weak

IV, intravenous; *NSAIDs*, nonsteroidal antiinflammatory drugs.

demonstrated that the addition of azithromycin to standard preoperative antimicrobial prophylaxis may be an effective strategy for reducing postoperative infections in this high-risk group[38]; this has not been compared directly to other regimens and remains an area of on-going study.

Summary

Preoperative antibiotic prophylaxis can reduce postpartum infection and related morbidity. Specific regimens and some distinct populations have been studied.

Recommendation: First generation cephalosporins should be used for antimicrobial prophylaxis with weight-based dose adjustments and administered within 60 minutes prior to skin incision to prevent postpartum infections.

Quality of evidence: High.

Strength of recommendation: Strong.

Recommendation: Azithromycin should be added to the preoperative

antibiotic prophylaxis regimen in patients undergoing unscheduled cesarean delivery.

Quality of evidence: High.

Strength of recommendation: Strong.

Recommendation: In patients living with obesity, antibiotic prophylaxis can include the addition of preoperative azithromycin or postoperative oral cephalexin plus metronidazole for 48 hours.

Quality of evidence: Moderate.

Strength of recommendation: Strong.

Abdominal or vaginal preparation

Abdominal preparation

Preoperative abdominal cleansing is recommended to reduce the risk of perioperative infection in all abdominal surgeries, with a growing body of evidence specific to cesarean deliveries. With regards to the prevention of SSI, skin preparation with chlorhexidine alcohol solutions appear to be slightly superior to aqueous iodine.[39,40] However, there is emerging evidence from research in other domains (eg, orthopedic and cardiac surgery) that chlorhexidine alcohol and iodine alcohol solutions may be equivalent.[41,42]

In RCTs and meta-analyses, chlorhexidine-based cleansers were found to be superior compared to povidone-iodine—based preparations in reduction of SSI rates,[43–46] but not in reduction of endometritis, following cesarean delivery.[47] One study assessed the use of chlorhexidine gluconate cloth wipes the evening before and morning of cesarean delivery in addition to abdominal preparation and found no difference in SSI or endometritis rates.[48] One RCT assessed the use of an additional incisional application of povidone-iodine after skin closure during unscheduled cesarean delivery and demonstrated no difference in SSI rates.[49]

Vaginal preparation

In patient undergoing cesarean delivery, vaginal preparation, mostly with aqueous iodine solution, has been shown to reduce infectious morbidity in women undergoing intrapartum cesarean delivery.[50,51] There have been a number of recent trials evaluating chlorhexidine gluconate (no alcohol) for vaginal preparation. One study reported on 204 Panamanian subjects randomized to placebo or 4% chlorhexidine gluconate vaginal wash, and found a significant reduction in endometritis (7.2% vs 18.8%) and puerperal fever (9.3% vs 19.8%) associated with chlorhexidine vaginal wash.[52] Similar results were reported in a Nigerian study with reductions of endometritis with vaginal preparation with chlorhexidine (36.8% vs 12%), but no reduction in puerperal fever.[53] Neither of these trials were of high quality. A United Kingdom pilot multicenter trial evaluating chlorhexidine vaginal preparation compared to placebo in 320 women undergoing unscheduled and scheduled cesarean delivery found a nonsignificant reduction in endometritis in the treatment group (0.7% vs 1.3%).[54] Another recent trial randomized 1114 subjects undergoing intrapartum cesarean delivery and found a statistically significant difference in the rate of wound infection—2.0% in patients receiving iodine vaginal preparation, compared to 0.6% of patients receiving chlorhexidine.[55]

Meta-analyses including a Cochrane review from 2020 demonstrate that either povidone-iodine or chlorhexidine for vaginal cleansing prior to cesarean delivery reduces postoperative infection, including SSI (4.1% vs 5.4%) and endometritis (3.4% vs 8.1%) with some evidence favoring povidone-iodine based preparations.[50,56–59] A subgroup analysis from the Cochrane review in 2020 suggested that there was a greater effect for patients undergoing intrapartum cesarean delivery, but that further research was needed.

Summary

Multiple clinical trials have demonstrated that abdominal and vaginal preparation reduce infectious postoperative morbidity. A chlorhexidine-based abdominal preparation may be superior to iodine, but the difference is likely to be modest. Vaginal preparation with aqueous iodine or 4% chlorhexidine prior to intrapartum cesarean delivery or with ruptured membranes is likely to reduce postoperative infection. More trials are needed to study vaginal preparation in various clinical settings, but chlorhexidine may be superior to aqueous iodine solutions.

Recommendation: Preoperative abdominal preparation with a chlorhexidine-based preparation is recommended prior to cesarean delivery.

Quality of evidence: Moderate.

Strength of recommendation: Strong.

Recommendation: Preoperative vaginal preparation with a chlorhexidine or povidone-iodine solution is recommended for patients undergoing intrapartum cesarean delivery or with ruptured membranes, and can be considered for scheduled cesarean delivery without ruptured membranes.

Quality of evidence: Low.

Strength of recommendation: Strong.

Antiemetic prophylaxis

Multitherapy antiemetic prophylaxis against postoperative nausea and vomiting (PONV) has been recommended for adult surgical patients with 1 or more risk factors by a prior consensus guideline.[60] The systematic review and meta-analysis supporting this recommendation reported a significant benefit for multitherapy (2 or more drugs) for both nausea and vomiting over 24 hours postoperatively but only for nausea in first 6 hours postoperatively.[61] A previous factorial trial in a mixed adult surgical population reported the incidence of any PONV within 24 hours was reduced from 52% with no antiemetics, to 37%, 28%, and 22% when 1, 2, and 3 antiemetics respectively were administered.[62] There were no significant differences in efficacy among the antiemetics or between any pair of antiemetics administered. A Cochrane review of the efficacy of PONV prophylaxis after cesarean delivery with antiemetic monotherapies evaluated 69 trials (n=8928 patients) whose evidence was graded as mostly low or very-low quality.[63] There were no significant differences between therapies in their efficacy to prevent either nausea or vomiting intraoperatively or postoperatively. Antiemetics that may be beneficial both intraoperatively and postoperatively included 5HT-3 antagonists, dopamine antagonists, and anticholinergics; steroids and antihistamines may be beneficial postoperatively.

A mixed network meta-analysis study of antiemetic prophylaxis to prevent PONV after cesarean delivery performed under neuraxial anesthesia using

neuraxial opioids evaluated 33 studies involving 4238 patients.[64] This study found that when compared to placebo, 5HT-3 antagonists, dopamine antagonists, dexamethasone, and combination of 5HT-3 antagonist/dexamethasone all reduced PONV. The combined 5HT-3 antagonist/dexamethasone achieved a greater reduction in PONV than the monotherapies but the 95% confidence intervals for the odds ratios for all therapies overlapped. Overall, quality of the evidence was graded as low or very low. Dexamethasone may be a preferred option in combination therapies, as a single dose given after cesarean delivery can improve postoperative pain management (lower early pain scores, reduced opioid consumption, prolonged time for first rescue analgesia).[65,66] Concern about the adverse effects on maternal glycemic control may prohibit the use of dexamethasone in patients with diabetes, although that concern has been challenged.[67,68] If dexamethasone is administered to patients with gestational diabetes it should be administered after delivery to reduce the risk of neonatal hypoglycemia.[69] There is no evidence to support the use of 3 or more prophylactic antiemetic therapies in the obstetric surgical population, and there is likely to be diminishing benefits for additional antiemetic drugs. The paucity of data on drug side effects and patient-reported experiences needs to be considered.

Summary

Dual antiemetic therapy with a combination of intraoperative 5HT-3 antagonist/dexamethasone or 5HT-3 antagonist/dopamine antagonist (eg, metoclopramide) has the best evidence for most benefit for reducing PONV after cesarean delivery, particularly when performed under neuraxial anesthesia using long-acting intrathecal opioids.

Recommendation: Multitherapy (dual agent) antiemetic prophylaxis.

Quality of evidence: Low.

Strength of recommendation: Strong.

Prevention and treatment of spinal anesthesia induced hypotension

Fetal perfusion is not autoregulated and is highly dependent on uteroplacental blood flow, varying directly with maternal blood pressure. Hypotension after spinal anesthesia is a frequent occurrence and may lead to maternal and neonatal adverse effects. As such, strategies should be employed to minimize maternal hypotension during cesarean delivery. A titratable prophylactic vasopressor infusion should be started after the administration of intrathecal medications to maintain maternal blood pressure within 90% of baseline value, and decreases below 80% of baseline should be avoided. Vasopressors which are predominantly alpha-adrenergic agonists (phenylephrine and norepinephrine) are the most appropriate drugs to prevent hypotension following spinal anesthesia and are associated with less neonatal acidosis then ephedrine.[70–73] Norepinephrine may be as effective as phenylephrine in preventing spinal anesthesia related hypotension[74] with the benefit of less maternal bradycardia.[75–77] Ephedrine boluses in conjunction with a phenylephrine infusion may be required to treat ongoing maternal blood pressure below 90% (especially if large doses of phenylephrine are required or with coexisting maternal bradycardia).[71]

Other measures to reduce hemodynamic disturbance are less effective but can reduce hypotension when used in combination with a vasopressor infusion. Crystalloid or colloid coloading is preferable to a preload or no fluid for preventing spinal hypotension. Reducing compression of the inferior vena cava by applying left lateral tilt to 15° and manual displacement of the uterus can reduce phenylephrine requirements (although this may be difficult practically after the start of surgery).[78,79] There are limited studies on the role of leg compression devices and leg elevation in minimizing hypotension with conflicting results.[80–83] A 2017 RCT demonstrated that leg elevation to 40° reduced the incidence of spinal hypotension and intraoperative vasopressor requirements.[81] A smaller 2020 study also showed a reduction in the incidence of spinal hypotension in women randomized to receive leg elevation versus no leg elevation during scheduled cesarean delivery.[82]

Summary

A phenylephrine infusion with intravenous fluid (IVF) coloading is the preferred method to prevent and treat maternal hypotension secondary to spinal anesthesia for cesarean delivery and has been associated with improved maternal and neonatal outcomes compared to ephedrine. Additionally, left lateral tilt or other uterine displacement techniques should be considered.

Recommendation: Maintain baseline maternal blood pressure with a variable rate vasopressor infusion and crystalloid coload.

Quality of evidence: Moderate.

Strength of recommendation: Strong.

Recommendation: Apply left lateral tilt or other uterine displacement techniques once the pregnant person is in the supine position on the operating table.

Quality of evidence: Low.

Strength of recommendation: Strong.

Maintenance of normothermia

Maintaining patient intraoperative normothermia (36°C–37°C) is a recommended standard of care in several national and ERAS guidelines, but unfortunately maternal hypothermia remains a common issue postcesarean delivery.[84–87] RCTs and meta-analyses suggest that perioperative patient hypothermia is a risk factor for increased surgical bleeding, SSI, postoperative myocardial ischemia, and prolonged postanesthetic recovery; many trials predate current practices using normothermic care bundles and include patients with core temperatures <35°C.[88–92] A Cochrane review (67 RCTs) of the benefits of active body surface warming (ABSW) showed a benefit for reduction of SSI.[93] A meta-analysis did not show an increase in harm for perioperative hypothermia 35°C to 36°C.[94] A large RCT (n=5056 patients) did not find any difference in the incidence of myocardial injury, SSI, and need for transfusion between those surgical patients having general anesthesia allocated to intraoperative core temperature maintained at 37° (active warming) or 35.5°C (no active warming).[95] The importance for enhanced recovery of postoperative patient

thermal comfort and absence of shivering should not be underestimated.

The skin is responsible for 90% of heat loss,[96] and the rate of heat loss is dependent on temperature gradient between the core body and external environment. At environmental temperatures at or below thermal comfort (26°C), radiation and convection are the main heat losses, mainly from thigh, leg, and chest.[97,98] Both general anesthesia and neuraxial anesthesia impair autonomic thermoregulation and prevent behavioral thermoregulation compensation by the patient. During the first hour of anesthesia there is a rapid decrease in core temperature mainly due to anesthesia-induced vasodilation causing redistribution core hypothermia.[95,99] The reduction of core temperature and inadvertent hypothermia risk will depend on various factors including the preinduction core temperature, area of skin exposure, environmental temperature, temperature of IVF infusions, and duration of surgical anesthesia.[97]

Various strategies to minimize the core temperature decrease have been adopted and their efficacy studied. Prewarming patients usually achieves a core temperature 0.4°C warmer than those not prewarmed.[97] For patients undergoing neuraxial anesthesia for cesarean delivery, prewarming with forced air and warmed IVFs was not significantly beneficial when subsequent intraoperative warming was limited to warmed IVFs and covering with a warmed cotton blanket, but in another trial, it was beneficial when forced air warming was continued intraoperatively.[100–102] A single layer of passive insulation, for example, a blanket, reduces skin heat loss by only 30% (50% with 3 layers).[97] Warmed IVFs will not increase core temperature but IVF at room temperature can reduce core temperature by 1.4°C which cannot be compensated by forced air warming.[103] A Cochrane review of 24 trials concluded that warmed IVF maintained core temperature about 0.5°C warmer than in patients given un-warmed IVF in obstetric and nonobstetric surgery.[104]

Small RCTs have failed to show that the addition of forced air warming to warmed IVF is beneficial for reducing maternal temperature decrease during neuraxial anesthesia for cesarean delivery.[105–107]

Two meta-analyses concluded that active warming strategies reduced the risk of maternal hypothermia compared to passive warming during cesarean delivery with neuraxial anesthesia.[108,109] Compared to a no active warming control group, using either warmed fluid or forced air warming during scheduled cesarean delivery reduced shivering and maternal hypothermia with a number needed to treat of 5 and 7, respectively.[106] There was no evidence that forced air warming had additional benefit to warm IVF for surgical anesthesia less than 60 minutes duration or that upper forced air warming blankets are better than lower body blankets for cesarean delivery.[110] For ABSW, forced air warming has been found to be more effective than resistive heating at reducing the incidence of hypothermia in elective in obstetric and nonobstetric surgery under general anesthesia.[111]

A higher ambient operating room temperature at 23°C compared to 20°C may have a beneficial effect for reducing hypothermia in patients (33% vs 27%, $P=.06$) and infants (19% vs 5%) $P<.001$), but 56% of surgeons reported discomfort at the higher temperature during higher humidity days.[112]

In awake patients during neuraxial anesthesia, zero heat flux (forehead), sublingual, or axilla have been recommended as alternatives to invasive temperature measurement sites, for example, distal esophagus, but with warning about possible inaccuracies beyond the 36.5°C to 37.5°C range with sublingual and axilla measurements.[82] Regular patient temperature measurement every 30 minutes is recommended during surgical anesthesia.[113]

Summary

Patients undergoing cesarean delivery should receive warmed IVFs and forced air warming to maintain normothermia.should be considered if the duration of surgical anesthesia is expected to exceed 60 minutes. Patients should be kept warm prior to surgery by wearing sufficient warm clothing, mobilizing if possible, and being in a warm environment. If this is not possible, then consider providing the patient with forced air warming. Temperature should be measured prior to induction of anesthesia and at 30-minute intervals during surgical anesthesia.

Recommendation: Interventions to encourage normothermia such as warmed IV fluids and forced air warming should be considered for cesarean delivery.

Quality of evidence: Moderate quality.

Strength of recommendation: Strong.

Maintenance of euvolemia

The objectives of perioperative fluid administration are to maintain euvolemia as well as tissue fluid and electrolyte homeostasis.[114] During cesarean delivery this facilitates oxygen delivery to maternal organs, including the uteroplacental unit, and thus may improve both maternal and neonatal perioperative outcomes. Pregnant patients are a population who may be more sensitive to the acute effects of fluid overload, and excessive fluid administration has also been shown to negatively impact neonatal outcomes.[115–117]

Similar to the discussion above regarding spinal anesthesia, attention to counteracting the hemodynamic effects of anesthesia, whether neuraxial or general, with administration of vasoactive medications and IVFs is an important consideration when aiming to maintain relative euvolemia.[118] Regarding goal-directed IVF therapy, while there is high-level evidence showing that it can improve outcomes including wound infection and hospital length of stay after major surgery, the evidence from patients undergoing cesarean delivery is sparse and inconsistent.[119,120]

Even greater hemodynamic care and attention is required for certain subpopulations undergoing cesarean delivery, such as those with cardiac disease, sepsis, or preeclampsia. Multidisciplinary planning is important in the more severe cases and invasive blood pressure and cardiac output monitoring may be helpful in guiding perioperative management and fluid therapy.

Summary

Preoperative and intraoperative euvolemia are important goals of pericesarean

care and can improve maternal and neonatal outcomes.

Recommendation: Manage IVFs to achieve euvolemia.

Rating of quality of evidence: low.

Strength of recommendation: strong.

Optimal use of uterotonic agents

Postpartum hemorrhage is a leading cause of maternal mortality globally and uterine atony is the most common etiology for postpartum hemorrhage. Uterotonic medications are routinely given after delivery to prevent postpartum hemorrhage. However, undesirable effects of uterotonic agents are common and include nausea, tachycardia, hypotension, and water retention (oxytocin), bronchospasm (prostaglandins such as carboprost), and hypertension (ergot alkaloids such as methylergonovine).[121,122] Therefore, appropriate dosing of these medications is important to avoid side effects and enhance postpartum recovery.

A 2021 network meta-analysis of uterotonic agents concluded that carbetocin (not available in the US) was probably the most effective agent and that oxytocin appeared to be more effective when initiated as a bolus.[123] While oxytocin or, where available, carbetocin are the most widely recommended first line agents, the advised dosing strategies vary substantially. Given the potentially harmful effects of excessive doses, particularly rapid bolus doses of oxytocin, it is advisable to adopt a dosing strategy that aims to achieve adequate uterine tone at the minimally effective dose, while efficiently proceeding to second line agents in cases of treatment failure.

A 2019 international consensus statement on the use of uterotonics during cesarean delivery suggested an oxytocin administration strategy which includes a small initial bolus dose and a rescue bolus dose should tone still be inadequate 2 minutes later, followed by a range of maintenance infusion rates (Table 3).[122] Their suggested dosing differed between scheduled and unscheduled cesarean delivery based on strong evidence that the larger doses were shown to be required in the latter context.[124–126] Additionally, advice to administer bolus doses of oxytocin no faster than 1 IU per 10 seconds reflects good quality evidence of slow administration to avoid the pronounced hemodynamic effects observed with rapid boluses.[127,128] A double-blinded noninferiority trial in 2022 concluded that for patients at low risk of postpartum hemorrhage with surgery performed under spinal anesthesia, lower doses of oxytocin (0.5 units IV followed by infusion) are noninferior to higher doses (5 units IV followed by infusion) for all measured outcomes including uterine tone scores, need for additional uterotonics, and blood loss.[129]

Summary

Employ an uterotonic administration strategy that aims to achieve adequate uterine tone at the minimally effective doses while efficiently proceeding to second line agents when necessary. Carbetocin and oxytocin are effective first line agents. Oxytocin is most effective when administered as an infusion after a slow initial bolus dose.

Intervention: Routine administration postdelivery oxytocin (or carbetocin) as first line agent for prophylaxis against uterine atony.

Rating of quality of evidence: moderate.

Strength of recommendation: strong.

TABLE 3
Suggested oxytocin administration strategies

Antepartum cesarean	Initiating bolus[a]: 1 IU
	Rescue bolus[a]: 3 IU if uterine tone inadequate after 2 min
	Maintenance infusion: 2.5–7.5 IU/h
Intrapartum cesarean	Bolus[a]: 3 IU
	Rescue bolus[a]: 3 IU if uterine tone inadequate after 2 min
	Maintenance infusion: 7.5–15 IU/h

[a] Administer bolus doses at a rate no faster than 1 IU per 10 s.

Multimodal analgesia

Multimodal analgesia combines 2 or more analgesia techniques in an effort to decrease systemic opioid requirement intra- and postoperatively and is enhanced by the addition of intrathecal opioids. Based on a 2021 systematic review that included 126 randomized trials, neuraxial hydrophilic opioids should be used to provide postoperative analgesia.[65] Preservative free intrathecal morphine (50–150 μg) or epidural morphine (1–3 mg) are recommended.[129–132] Lipophilic opioids such as fentanyl (10–15 μg) when given in combination with intrathecal local anesthetic agents have been shown to reduce the need for intraoperative analgesia supplementation and the incidence of nausea and vomiting (but with an increased incidence of pruritus).[133]

Nonopioid agents play a crucial role in opioid-sparing multimodal analgesia. Oral acetaminophen (975 or 1000 mg) should be initiated before surgery or intravenously after delivery if not administered preoperatively.[134] IV nonsteroidal antiinflammatory drugs (NSAIDs) such as ketorolac (15–30 mg) should be given at the end of surgery in the absence of contraindications. Recently, a single dose of intraoperative dexamethasone has been recommended for analgesia but studies have not consistently demonstrated a reduction in pain scores or postoperative opioid consumption.[129,135,136] If neuraxial morphine is not administered, then local anesthetic supplemental strategies should be considered including wound infiltration (single shot), continuous wound infusion, and/or fascial plane blocks such as transversus abdominis plane blocks, erector spinae plane blocks, or quadratus lumborum blocks.

Summary

Multimodal analgesia initiated before or during surgery as part of an enhanced recovery protocol decreases systemic

opioid use after elective cesarean delivery. Specific recommendations include:

Recommendation: Intrathecal morphine to improve postoperative analgesia.

Quality of evidence: High.

Strength of recommendation: Strong.

Recommendation: Preoperative or intraoperative acetaminophen.

Quality of evidence: Moderate.

Strength of recommendation: Strong.

Recommendation: Intraoperative NSAIDs.

Quality of evidence: High.

Strength of recommendation: Strong.

Recommendation: Intraoperative dexamethasone to enhance multimodal analgesia may be considered.

Quality of evidence: Low.

Strength of recommendation: Weak.

Recommendation: Supplemental local blocks if intrathecal morphine is not used.

Quality of evidence: High.

Strength of recommendation: Strong.

Early initiation of skin-to-skin care of neonate

Though the majority of ERAS interventions focus on the pregnant and postpartum patient outcomes, there are RCTs which report on neonatal outcomes following implementation of ERAC including breastfeeding success and neonatal transition to postnatal life.

Breastfeeding success.

Breastfeeding-related outcomes are improved with early skin-to-skin initiation and ERAC bundles. One study reported that skin-to-skin contact after cesarean delivery facilitated breastfeeding in 92% of neonates compared to 32% in the no skin-to-skin group, which was sustained at 1 month (92% in the skin-to-skin group and 12.5% in the no skin-to-skin group).[137] Initiation of breastfeeding within the first 60 minutes of cesarean delivery occurred in 56%, 71% and, 72% of neonates who had skin-to-skin contact for 30, 60, and 90 minutes after birth, respectively, compared to 22% in the control group.[138] Another study reported that skin-to-skin contact during surgery resulted in exclusive breastfeeding at discharge after cesarean delivery in 90% of patients as compared to 70% of those who started skin-to-skin after surgery.[139] A retrospective study reported that 94% of the women who experienced skin-to-skin care in the operating room breastfed their newborns compared to 63% who did not experience skin-to-skin care in the operating room.[140] Moreover, 75% of the women were exclusively breastfeeding at time of discharge in the skin-to-skin care group as compared to 44% who did not experience skin-to-skin care in the operating room. Paternal skin-to-skin care after cesarean delivery is also beneficial, with earlier initiation of breastfeeding.[141] It is important to note that in nonrandomized studies of skin-to-skin and breastfeeding, confounding due to patient characteristics and preferences toward breastfeeding likely exist. However, in a randomized trial of ERAC implementation, it was reported that breastfeeding at discharge occurred for 67% newborns in the ERAC group compared to 48% in those randomized to the non-ERAC group.[142] Additionally, a pre-post implementation study reported an 80% breastfeeding rate post-implementation of ERAC program compared to 67% in the pre-implementation group.[143] A study of the implementation of ERAC facilitated earlier breastfeeding within the first 6 hours after delivery (first hour: 0% vs 50%, 2−4 hours postop: 33% vs 35%; >5−6 hours: 67% vs 15%).[144] Thus, the majority of studies have reported positive breastfeeding outcomes following implementation of immediate or early skin-to-skin care. None of the studies have reported any untoward side effects or adverse events associated with ERAS program implementation for newborns.

Neonatal transition to postnatal life

A randomized trial reported that intraoperative skin-to-skin exposure as compared to postoperative skin-to-skin exposure was not associated with any differences in neonatal transition or the stress response.[145] An RCT of fathers holding the baby and performing skin-to-skin care immediately after cesarean delivery reported a prolonged state of neonatal wakefulness, suggestive of a more adaptive state and smoother transition to postnatal life.[146] This was supported by another RCT[140] that found that paternal skin-to-skin care after scheduled cesarean delivery results in more stable neonatal heart rate and temperature, reduced duration of crying, and earlier breastfeeding initiation compared to no skin-to-skin care.

Summary: Overall, implementation of early skin-to-skin care by the birthing or nonbirthing parent shows benefits with regards to breastfeeding success and neonatal transition, with no apparent harm for neonates.

Recommendation: Early initiation of skin-to-skin care should be implemented (birthing or nonbirthing) to improve breastfeeding success.

Evidence level: Moderate.

Recommendation: Strong.

Recommendation: Early initiation of skin-to-skin care can facilitate a smoother postnatal adaptation.

Evidence level: Very low.

Recommendation: Weak.

Comment

The intraoperative ERAC interventions described above can reduce the frequency of spinal hypotension, nausea and vomiting, hypothermia, and uterine atony, and improve pain control which may impact postdelivery infections and hemorrhage. Unfortunately, the quality of evidence for many of the interventions was not high and was low or very low for many. Thus, it is imperative that high quality research on these interventions is conducted to provide better guidance. Until then, the 19 recommended interventions in the ten intervention categories outlined in this manuscript represent the best evidence to date and should be implemented for patients undergoing cesarean delivery in the absence of contraindications, in order to optimize patient experience, satisfaction, and recovery following cesarean delivery. ■

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