Guidelines for Antenatal and Preoperative care in Cesarean Delivery: Enhanced Recovery After Surgery Society Recommendations (Part 1)

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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.[1,2] Bisch et al[3] reported on the ERAS use in gynecologic oncology with the conclusion that the systematic implementation of ERAS gynecologic oncology guidelines across a healthcare system improves patient outcomes and saves resources. ERAS has been shown to

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This Enhanced Recovery After Surgery (ERAS) Guideline for perioperative care in cesarean delivery will provide best practice, evidenced-based, recommendations for preoperative, intraoperative, and postoperative phases with, primarily, a maternal focus. The focused pathway process for scheduled and unscheduled cesarean delivery for this ERAS Cesarean Delivery Guideline will consider from the time from decision to operate (starting with the 30—60 minutes before skin incision) to hospital discharge. The literature search (1966—2017) used Embase and PubMed to search medical subject headings that included "Cesarean Section," "Cesarean Section," "Cesarean Section Delivery" and all pre- and intraoperative ERAS 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 that 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 ERAS Guidelines. The ERAS 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 ERAS cesarean delivery consensus recommendations preoperative elements (anesthetic medications, fasting, carbohydrate supplementation, prophylactic antibiotics/skin preparation,), intraoperative elements (anesthetic management, maternal hypothermia prevention, surgical technique, hysterotomy creation and closure, management of peritoneum, subcutaneous space, and skin closure), perioperative fluid management, and postoperative elements (chewing gum, management of nausea and vomiting, analgesia, timing of food intake, glucose management, antithrombotic prophylaxis, timing of ambulation, urinary management, and timing of maternal and neonate discharge). Limited topics for optimized care and for antenatal education and counselling and the immediate neonatal needs at delivery are discussed. Strong recommendations for element use were given for preoperative (antenatal education and counselling, use of antacids and histamine, H2 receptor antagonists, 2-hour fasting and small meal within 6 hours surgery, antimicrobial prophylaxis and skin preparation/chlorhexidine-alcohol), intraoperative (regional anesthesia, prevention of maternal hypothermia [forced warm air, warmed intravenous fluids, room temperature]), perioperative (fluid management for euvolemia and neonatal immediate care needs that include delayed cord clamping), and postoperative (fluid management to prevent nausea and vomiting, antiemetic use, analgesia with nonsteroidal antiinflammatory drugs/paracetamol, regular diet within 2 hours, tight capillary glucose control, pneumatic compression stocking for venous thromboembolism prophylaxis, immediate removal of urinary catheter). Recommendations against the element use were made for preoperative (maternal sedation, bowel preparation), intraoperative (neonatal oral suctioning or increased inspired oxygen), and postoperative (heparin should not be used routinely venous thromboembolism prophylaxis). Because these ERAS cesarean delivery pathway recommendations (elements/processes) are studied, implemented, audited, evaluated, and optimized by the maternity care teams, this will create an opportunity for the focused and optimized areas of care research with further enhanced care and recommendation.

Key words: cesarean delivery, enhanced recovery, intraoperative, postoperative, preoperative, quality, safety

AJOG at a Glance

Why was this study conducted?

This ERAS Society Guideline was created to support the most common surgical procedure in the industrialized healthcare world, the cesarean delivery. This ERAS cesarean delivery guideline 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 ERAS 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 after delivery.

What does this add to what is known?

This ERAS Cesarean Delivery Guideline has taken the evidence-based knowledge that has been created from the cesarean delivery research, has evaluated it critically, and, with authorship consensus, has published recommendations for process-directed maternal care for the pre-, intra-, and postoperative cesarean delivery timing in a 3-part guideline with the use of the ERAS Society principles and process for improved surgical quality and safety for obstetric surgical deliveries that promote enhanced recovery for maternal and neonatal outcomes.

result in both clinical benefits (reductions in length of stay, complications, and readmissions) and health system benefits (reduction in cost).[1−3]

ERAS is a tool for process management, creating a focused care process. The use of audit and feedback allows an implementation process, 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. This ERAS process will enhance the quality of care, patient safety, and health outcomes.

ERAS Guideline for perioperative care in cesarean delivery will provide evidenced-based practice recommendations for preoperative (Part 1), intraoperative (Part 2), and postoperative (Part 3) phases and allow audit assessment and measurement of the desired outcome. Although certain ERAS principles have been established for other abdominal/pelvic surgeries,[3,4] this present ERAS Cesarean Delivery (ERAS CD) pathway will provide additional evidenced-based recommendations for the surgical pathway related to cesarean delivery with, primarily, a maternal focus. The "focused" pathway process for scheduled and unscheduled ERAS CD has been created, for the complete ERAS CD Guideline (Parts 1−3), from decision-to-operate (30−60 minutes before skin incision) to hospital discharge, which includes the immediate neonatal care. The Appendix (Part 1) has additional information that would assist providers with optimizing the maternal antenatal care when comorbidities are present that may impact maternal and neonatal heath with additional potential operative impact.

As a final introduction comment, Panda et al[4] researched clinicians' views of factors for cesarean delivery using systematic review and metasynthesis of qualitative, quantitative, and mixed methods. Three main themes were identified: (1) clinicians' personal beliefs, (2) healthcare systems (litigation, resources, private vs public insurance payments, guidelines, management policy), (3) clinicians' characteristics (personal convenience, clinicians' demographics, confidence, and skill).

Obstetricians and midwives are directly involved in the decision to perform a cesarean delivery, and once the decision is made a process with evidence-based factors and decreased variance for enhanced recovery is being proposed.

Methods

Literature search

The author group was selected and vetted by the ERAS Society Guideline Committee in May 2017 based on international expertise in the area, and a consensus ERAS CD−enhanced recovery topic list was determined. The ERAS Gynecologic/Oncology guidelines[5,6] 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 that included "Cesarean Section," "Cesarean Delivery," "Cesarean Section Delivery," and all pre- and intraoperative ERAS items. 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. Metaanalyses, 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 system,[7] as used and described in previous ERAS Guidelines (Table 1).[5−7] 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. **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 (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 and senior authors.

Recommendations for each ERAS CD element in pre-/intra-/postoperative (Parts 1–3) have been identified, discussed, and agreed upon with the preoperative ERAS CD (Part 1) elements presented in Table 2.

TABLE 1
Grading of Recommendations, Assessment, Development and Evaluation system for rating quality of evidence[5]

Rating quality	Definition
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 the estimate of effect and may change the estimate
Low quality impact on confidence estimate	Further research is very likely to have important impact on confidence estimate of effect and likely to change the estimate
Very low quality	Any estimate of effect is very uncertain
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

Caughey. ERAS for cesarean delivery. Am J Obstet Gynecol 2018.

Results

Antenatal and preoperative ERAS CD topics (Part 1)

The cesarean delivery pathway and the process elements have a wider scope for the maternal antenatal and preoperative-natal care and can be considered within the ERAS CD pathways.

The preoperative pathway is a focused pathway that starts 30–60 minutes before the cesarean incision and ends at maternal (fetal) discharge from hospital, which allows for a more consistent and generalizable ERAS CD process that includes the same comprehensive care to both unscheduled and scheduled cesarean delivery.

An antenatal optimized pathway start from 10–20 weeks of gestational age with a highlighted clinical process for maternity care by a multidisciplinary team to support preadmission information, education, counselling, and maternal comorbidities (ERAS CD Expanded Program). Within the clinical scenario, there are complex maternity patients who may require an unplanned cesarean delivery but may need access to the team-based optimized antenatal care to minimize the operative risks for themselves and their offspring, if surgery is required.

Corso et al[8] undertook a rapid review of clinical protocols and an umbrella review of systematic reviews that are related to enhanced recovery after elective cesarean delivery. They identified 5 clinical protocols with a total of 25 clinical components, with 3 (early oral intake, mobilization, removal of the urinary catheter) of the 25 components present in all 5 protocols. The Appraisal of Guidelines for Research and Evaluation II scores were generally low. Systematic reviews of single components identified a reduced length of stay after cesarean delivery of 0.5–1.5 days with the use of the studied factors (minimally invasive Joel-Cohen surgical technique, early catheter removal, postoperative antibiotic prophylaxis). They concluded that more ERAS CD research is required to evaluate and audit directed pathways for enhanced recovery.[8]

A 2013 systematic review for cesarean delivery had the objective to provide an updated evidence-based guide for surgical decisions during the cesarean delivery.[9] Recommendations, with a high level of certainty for clinical value, were made for pre–skin incision prophylactic antibiotics, cephalad-caudad blunt uterine extension, spontaneous placental removal, and surgeon preference on uterine exteriorization; single layer uterine closure when future fertility is undesired, and suture closure of the subcutaneous tissue when the thickness is $\geq$2 cm.[9] No clinical value was found for manual cervical dilation for uterine drainage, subcutaneous drains in the wound, or maternal supplemental oxygen for the reduction of infective morbidity.[9]

These systematic reviews, subsequent other systematic reviews, and meta-analyses in the reference lists have been used in this ERAS CD Guideline to evaluate the present status of the previous and new clinical care factors for the enhanced quality, safety, and recovery of pregnant women who require a cesarean delivery.

Antenatal preadmission information, education, and counselling (Optimized Element)

Appropriate antenatal care should include preparation of pregnant women and their partners for delivery, which includes the possibility of either vaginal or surgical delivery. Documentation of a preadmission information and counselling process should include when the procedure will occur, the type of procedure, by whom the information was provided, and a comment on how the information was accepted or understood by the patient. Additionally, because unscheduled or emergent cesarean

TABLE 2
Guidelines for perioperative care in cesarean delivery: Enhanced Recovery After Surgery (ERAS) Society recommendations

Item	Recommendation	Evidence level	Recommendation grade
Antenatal pathway: OPTIMIZED			
Preadmission information, education and counselling (optimized element)	1. Although high-quality evidence is lacking, good clinical practice includes informing the patient about procedures before, during, and after cesarean delivery. The information should be adapted to whether cesarean delivery is an unscheduled or is a scheduled surgery.	Very Low-Low	Strong
	2. Cesarean delivery without medical indication should not be recommended without a solid preadmission evaluation of harms and benefits, both for the mother and her baby.	Very Low-Low	Strong
Preoperative pathway: FOCUSED			
Preanesthetic medications (focused elements)	1. Antacids and histamine H2 receptor antagonists should be administered as premedication to reduce the risk from aspiration pneumonitis.	Low	Strong
	2. Preoperative sedation should not be used for scheduled cesarean delivery because of the potential for detrimental effects on the mother and neonate.	Low	Strong
Preoperative bowel preparation (focused element)	1. Oral or mechanical bowel preparation should not be used before cesarean delivery.	High	Strong
Preoperative fasting (focused element)	1. Women should be encouraged to drink clear fluids (pulp-free juice, coffee, or tea without milk) until 2 hours before surgery.	High	Strong
	2. A light meal may be eaten up to 6 hours before surgery.	High	Strong
Preoperative carbohydrate supplementation (focused element)	1. Oral carbohydrate fluid supplementation, 2 hours before cesarean delivery, may be offered to nondiabetic women.	Low	Weak
Appendix: Preoperative maternal comorbidity optimization (optimized elements)	1. Maternal obesity (body mass index, >40 kg/m^2) significantly increases risks of maternal and fetal complications. Optimal gestational weight gain management should be used to control their weight during pregnancy. Surgical complexity requires multidisciplinary planning.	High	Strong
	2. Maternal hypertension should be managed during pregnancy because maternal chronic hypertension has been found to increase significantly the incidence of maternal and fetal morbidity and cesarean delivery.	High	Strong
	3. Maternal gestational diabetes mellitus has been found to significantly increase the risk for maternal and fetal morbidity. Maternal diabetes should receive timely and effective management during preconception and pregnancy.	High	Strong
	4. Maternal anemia during pregnancy is associated with low birthweight, preterm birth, and increases perioperative morbidity and mortality rates. The cause of the anemia should be identified and corrected.	Moderate	Strong
	5. Maternal cigarette smoking is associated with adverse medical and reproductive morbidity and should be stopped before or in early pregnancy.	High	Strong

Caughey. ERAS for cesarean delivery. Am J Obstet Gynecol 2018.

deliveries can occur with very little lead time, it is important to inform all women about the potential need for a cesarean delivery and the risks, benefits, and alternatives of the procedure.

In case of a cesarean delivery, information about the procedure before, during, and after the cesarean delivery should be provided. The information and recommendations will differ in relation to whether there is a clear medical indication for caesarean delivery or whether surgery is performed on maternal request. Maternity and support providers should also adapt their communication to the required situation, such as to whether the cesarean delivery was unscheduled or was a repeat (indicated/rejected vaginal birth after cesarean delivery (VBAC) or not a VBAC candidate/not indicated) or primary cesarean delivery.

In an unscheduled cesarean delivery, the informed consent process demands

instructive and reassuring behavior with clear and essential information to the patient or partner presented by the attending surgeon, appropriate level obstetrics trainee, and anesthesiologist. In this unscheduled situation, a short description of the indication for the cesarean delivery, the recommended type of anesthesia, and the surgical information related to the procedure and its urgency is important.

When a need for neonatal care of the newborn infant is identified and when time allows, the pregnant woman and her partner should have the option to meet a neonatologist or pediatrician and to visit the neonatal unit before the cesarean delivery is performed.

Cesarean delivery without a medical indication should not be considered without a comprehensive preadmission evaluation of harms and benefits for both the mother and her baby.[10–13] Information about the increased surgical risk of short-term complications (injuries to the abdominal organs, postoperative infection, thrombosis, and pain)[14–17] and the known long-term effects (risk of uterine rupture and placental complications in subsequent pregnancies)[18–21] should be compared with the benefit and risk profile of vaginal delivery as part of the preoperative counselling.

Short-term outcomes for the infant[22–25] and associations to longer term outcomes in childhood[21,26–31] should be discussed. In an evaluation of longer term outcomes that are associated with scheduled cesarean delivery, it is important to help the pregnant woman interpret the relative and absolute risks for different pediatric chronic disorders in childhood and young adulthood that are associated with cesarean delivery and that, although the underlying mechanisms remain to be explored, causality has not been proved.[32–34]

Summary and recommendations

(1) Although high-quality evidence is lacking, good clinical practice includes informing the patient about procedures before, during, and after cesarean delivery. The information should be adapted to whether cesarean delivery is an unscheduled or is a scheduled surgery (Evidence Level: Very Low/Recommendation Grade: Strong). (2) Cesarean delivery without medical indication should not be recommended without a solid preadmission evaluation of risks and benefits, both for the mother and her baby. (Evidence Level: Very Low/Recommendations Grade: Strong).

Antenatal optimization of maternal comorbidities and their impact on a cesarean delivery is beyond the scope of this direct and focused ERAS process/pathway guideline. A limited maternal comorbidity (body mass index, chronic hypertension, diabetes mellitus, iron deficiency anemia) and a pregnancy outcome summary are provided in the Appendix for the interested maternity providers because these maternal factors have perinatal and surgical impact.

Preoperative pathway

This focused preoperative 30- to 60-minute time period is very compressed for the women who undergo an unscheduled cesarean delivery because the scheduled cesarean delivery allows for an expanded antenatal/preoperative knowledge translation.

A checklist for the focused ERAS CD will allow for the patient and operative staff to have a summarized version of the informed knowledge that the patient requires and the overall ERAS CD pre-/intra-/postoperative elements (Figure 1[35–39]). Some of the pre- and intraoperative elements will have a different time sequence, which is dependent on the individual surgical team processes, but all elements are covered in ERAS CD Parts 1 and 2.

Preoperative anesthetic medications (Focused Element)

Although rare, aspiration pneumonitis is still a cause of maternal death during anesthesia for a cesarean delivery, even in well-resourced countries.[40] Interventions to reduce the risk of aspiration pneumonitis, at cesarean delivery, have been considered.[41] Although the quality of evidence was poor, it was found that the preoperative administration of a combination of antacids (nonparticulate sodium citrate to neutralize gastric acid) and histamine H2 receptor antagonists (ranitidine act by inhibiting the secretion of acid into the stomach decreasing both volume and acidity) was more effective than no intervention and was superior to antacids alone in the prevention of low gastric pH. Although these findings were for women who had a general anesthetic, they still have some relevance for cesarean delivery, under regional techniques, because a proportion of the women may require conversion to general anesthesia.

The preoperative administration of gabapentin has been found to improve postcesarean delivery pain control in some,[42,43] but not all,[44] studies. However, a systematic review of perioperative gabapentin for postoperative pain management for a variety of different types of surgery found little benefit, with an increased incidence of serious adverse events.[45]

One study that considered postcesarean delivery maternal sedation (either scheduled or unscheduled cesarean delivery surgeries)[46] reported more sedation (self-reported or observer assessment) after the unscheduled cesarean delivery surgery. Sedating medications (fentanyl, midazolam, meperidine, ketamine) were given more frequently in the unscheduled cesarean delivery group for management of side-effects and breakthrough pain. It has been suggested that maternal sedation may delay skin-to-skin contact between mother and baby and therefore should be used judiciously.[47]

There is little published information regarding the use of sedative premedication before cesarean delivery. The administration of benzodiazepines in pregnancy have been associated with "floppy baby syndrome,"[47,48] disturbed neonatal thermogenesis,[41] and lower Apgar scores.[48] A Cochrane review of sedative premedication for adult outpatient surgery found that there was an impairment in psychomotor function up to 3 hours after the operation (total 11 studies: 3/11 no effect; 6/11 some effect; 2/11 significant effect).[49] Therefore considering the potential for maternal and neonatal side-effects, preoperative sedation should be avoided.

FIGURE
Checklist for focused Enhanced Recovery After Surgery (ERAS) cesarean delivery patient "informed knowledge"

The patient/maternal has a clear understanding of the following factors:

1. The reason/indication for the cesarean delivery
2. The location and type of abdominal laparotomy incision
3. The abdominal skin incision closure technique that is used by the attending surgeon (randomized controlled trial evidence supports subcuticular skin closure for patient satisfaction and cosmetic outcome[1])
4. The preventive efforts that are used to minimize postoperative maternal infective morbidity (wound/uterus/pelvis/bladder); estimated prevalence of 3–15%[2,3]
5. The patient's estimated individualized postoperative risk assessment for thromboembolism and whether additional medical prophylaxis is needed beyond the standard mechanical techniques (elastic stockings or sequential compression devices); estimated prevalence is 0.5–2.2 per 1000 pregnancies or prevalence of venous thromboembolism ranges from 1–2 per 1000, with 80% an indication of antepartum deep vein thrombosis and 20–25% an indication of pulmonary embolism[4]; pulmonary embolism, 40–60% after delivery[5]
6. The gastrointestinal/oral intake plans for pre- and postoperative time periods
7. The anticipated postoperative activities and locations of mother and baby

List of ERAS cesarean delivery elements:

Preoperative

1. Anesthetic medications
2. Fasting
3. Carbohydrate supplementation
4. Antimicrobial prophylaxis
5. Skin wash/vaginal preparation to minimize infectious risk
6. Procedures for prevention of intraoperative hypothermia

Intraoperative

1. Pre- and intraoperative anesthetic management
2. Abdominal/vaginal antimicrobial cleansing
3. Cesarean delivery surgical techniques (opening-delivery-closure)
4. Perioperative fluid management
5. Neonatal immediate care/delayed cord clamping

Postoperative

1. ERAS sham feeding/chewing gum
2. Nausea and vomiting management
3. Analgesia
4. Perioperative nutritional care/early feeding
5. Glucose control
6. Thromboembolism prevention
7. Early mobilization
8. Urinary drainage management

Maternal and neonate discharge

Caughey. ERAS for cesarean delivery. Am J Obstet Gynecol 2018.

Summary and recommendations. (1) Antacids and histamine H2 receptor antagonists should be administered as premedication to reduce the risk from aspiration pneumonitis (Evidence Level: Low/Recommendation Grade: Strong). (2) Preoperative sedation should not be used for scheduled cesarean delivery because of the potential for detrimental effects on the mother and neonate (Evidence Level: Low /Recommendation Grade: Strong).

Bowel preparation (Focused Element)

Preoperative oral and/or mechanical bowel preparation has been used primarily in colorectal surgery to prevent postoperative infection and anastomotic leak. However, a recent metaanalysis,[50] which included gynecologic surgery trials,[51] found no benefit of bowel preparation. The only clear effect was to cause a "more unpleasant patient experience."

There is only 1 small clinical trial of mechanical bowel preparation before cesarean delivery that did not document any benefit.[52]

Summary and recommendation. Oral or mechanical bowel preparation should not be used before cesarean delivery (Evidence Level: High/Recommendation Grade: Strong).

Preoperative fasting (Focused Element)

Preoperative fasting was first described as a measure to prevent vomiting after the use of ether anesthetics. After a syndrome of post-operative aspiration pneumonia was described, it became more common to recommend fasting periods increase from 6 hours to the standard "NPO after midnight."[53] A Cochrane Review concluded that there was no increase in the volume or decrease in pH of gastric contents or an increase in complications with shorted preoperative fasting intervals.[54] The European Society of Anaesthesiology Guideline recommended that adults and children should be encouraged to drink clear fluids up to 2 hours before elective surgery (including cesarean delivery). Solid food should be prohibited for 6 hours before elective surgery in adults and children.[55] There have been no "fasting" trials in cesarean delivery patients, but 2 trials found similar results in patients immediately after delivery.[56,57] Contemporary perioperative guidelines, which include cesarean delivery, reflects these data and this approach.[55,58–65]

Summary and Recommendations. (1) Women should be encouraged to drink clear fluids (pulp-free juice, coffee, or tea without milk) until to 2 hours before surgery (Evidence Level: High/Recommendation Grade: Strong). (2) A light meal may be eaten up to 6 hours before surgery (Evidence Level: High/Recommendation Grade: Strong).

Preoperative carbohydrate supplementation (Focused Element)

There have been multiple trials of oral carbohydrate supplementation use up to 2 hours before surgery. A Cochrane Review found most trials had a high risk of bias and that treatment was associated with only a small reduction in the length of stay (0.3 days) and a decreased time to passage of flatus (0.39 days). Overall, postoperative complications were not changed, and there were no reported cases of aspiration pneumonia.[66]

Patient outcomes may be improved by a shorter fasting period preceded by prescribed carbohydrate intake. Postoperative insulin is preserved by carbohydrate drinks (100 g the night before surgery and 50 g 2 hours before surgery/intravenous glucose 5 mg/k/min).[67] Metaanalysis of low-to-moderate quality and small clinical trials indicate more evidence is required to establish benefit.[68,69]

The use of carbohydrate loading, preoperatively, is controversial and unaccepted for pregnant women with diabetes mellitus. The preoperative use of carbohydrate loading in the nonpregnant patient with diabetes mellitus was evaluated in a prospective, noninferiority cohort; preoperative carbohydrate loading was found to be noninferior to fasting, and neither group showed superiority for preoperative blood glucose concentration, hyperglycemia, or length of stay.[70]

Several clinical trials have evaluated carbohydrate supplementation or feeding in labor to improve labor outcomes. Although ineffective for this purpose, the practice appears safe.[71] There are no trials of oral carbohydrate supplementation before cesarean delivery for either pregnant diabetic or nondiabetic women.

Summary and recommendation. Oral carbohydrate fluid supplementation, 2 hours before cesarean delivery, may be offered to nondiabetic pregnant women (Evidence Level: Low/Recommendation Grade: Weak).

Comment

In North America, the most common indication to be admitted to 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 area because there are always ≥2 patients (mother and fetus[es]) impacted.

There are quality, industry-based "Deming Principles" that can be directed toward healthcare process management[72]: 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). Certain 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, process change has been initiated, but the clinical care goals have not been achieved.[73]

The indications for a cesarean delivery were summarized by the Maternal Fetal Medicine Unit Network[74]: primary indications (dystocia, 37%; nonreassuring fetal heart rate, 25%; abnormal fetal presentation, 20%; other, 15%; failed forceps or vacuum delivery, 3%); repeat indications (no VBAC attempt, 82; failed VBAC attempt, 17%; failed forceps or vacuum delivery, 0.4%).

Cesarean delivery has associated risk and benefit profiles for both processes of unscheduled or scheduled surgery. Complications that are associated with unscheduled (emergency) care and the time from decision to incision have been evaluated.[75] The maternal and neonatal outcomes were compared for decision to incision of <30 minutes (1814 patients) and >30 minutes (994 patients). The adverse maternal outcomes for decision to incision of <30 minutes compared with >30 minutes were endometritis (11.7%; 13.0%), wound complication (1.3%; 0.9%), and operative injury (0.3%; 0.5%), respectively, in the later timed cohort. The adverse neonatal outcomes were 5-minute APGAR ≤3 (1.0%; 0.9%), umbilical artery pH <7.0 (4.8%; 1.6%), hypoxic ischemic encephalopathy (0.7%; 0.5%), fetal death in labor (0.2%; 0%), and neonatal death with no malformation (0.4%; 0.1%) and with malformations (0.4%; 0.3%), respectively. Hypoxic ischemic encephalopathy was the only significant comparison (P=.001) against the <30-minute delivery group.

Complications associated with pregnancy outcomes after a scheduled low-risk cesarean delivery (46,766 patients) and planned vaginal birth (2,292,420

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

Nonmodifiable clinical factor	Modifiable clinical factors/audit
Maternal age	
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 <34 weeks gestation)
Family history (genetics/birth defects/multifactorial disease)	Surgical pathway (preoperative; intraoperative; postoperative)
Gestational weeks 0–20 (chromosomes/birth defects/miscarriage)	

Caughey. ERAS for cesarean delivery. Am J Obstet Gynecol 2018.

patients) have been reported.[76] The overall maternal morbidity (cesarean delivery, 2.23%; vaginal birth, 0.9%) was not significant for all comparisons.[76] Other investigators have reported a 2-fold increase for cesarean delivery with an increased morbidity outcome as the result of puerperal infection, hemorrhage, and thromboembolism.[77,78]

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 accrete (0.25−3%).[79]

Initiatives to reduce the frequency of cesarean delivery and enhance maternal safety have been proposed.[80]

The focused ERAS CD pathway (Parts 1−3) will summarize the evidenced-based preoperative, intraoperative, and postoperative clinical care processes. The ERAS CD (Part 1) Antenatal/Preoperative recommendations with the level of evidence and the recommendation grade are summarized in Table 2. Each of the elements or processes within the focused ERAS CD pathway has the opportunity to be measured, compared between services/providers, and improved as required. The optimized ERAS CD elements have a broad antenatal clinical scope that add complexity, but the management of the comorbid maternal factors should be considered for enhanced outcomes.

Quality and safety elements to consider, for the creation of a clinical audit tool, require that[81] (1) the audited pathway has an important impact in terms of costs, resources, or risk, (2) strong scientific evidence is available, and (3) improvements to be made on the topic in question can be evaluated easily and become a source of important clinical/organizational consequence.

The purpose of quality improvement is to enhance the safety, efficiency, and effectiveness in the multiple areas of the healthcare process. Surgical obstetric healthcare has become a more delegated "team sport" but 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 system- and human-based variance, team building practice (simulation), and the introduction of new training approaches and oversight.

The ERAS CD Guideline/Pathway (Part 1) has initiated a Focused Pathway (for scheduled and unscheduled surgery starting from 30−60 minutes before skin incision to maternal discharge) with 4 focused preoperative elements with 6 recommendations: 3 recommendations are strong for their use, antacids and histamine H2 receptor antagonists, fasting only 2 hours, and small meal within 6 hours before surgery; 2 recommendations against their use, maternal sedation, and bowel preparation, and 1 recommendation for antenatal optimized element (2 strong recommendations for use; Table 2).

This 3-part ERAS CD Guideline/Pathway will follow with intraoperative (Part 2) and optimized immediate neonatal care elements and postoperative (Part 3) to maternal discharge.

The maternity clinical care process has both normal and complex pathways that are dependent on the patient's a priori obstetric risk, but there are increasing risk management factors for the maternal and fetal patient that are related to obstetric comorbid medical, genetic, surgical, and lifestyle factors. More prospective and quality assessment/improvement research, evaluation, audit, and collaboration will be required for enhancement of the maternal and fetal health outcomes, quality, and safety. ■

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Appendix: Early Recovery After Surgery (ERAS) cesarean delivery (CD): Part 1 Pathway and Appendix Table 1

ERAS CD: antenatal optimization (Optimized Element)

Preoperative medical optimization is an important clinical goal for better surgical outcomes and requires multidisciplinary team-based care. This ERAS CD optimization is directed at women who are pregnant with a comorbidity and is not directed at preconception care. Evidence supports that modifiable clinical factors for the pregnant woman could include body mass index (obesity), preexisting hypertension, preexisting diabetes mellitus, and anemia.[1,2] Pregnancy-associated hypertension and diabetes mellitus require optimization after diagnosis that is based on severity and gestational age. Although preexisting obesity (body mass index >40 kg/m^2 prevalence of 7%) impacts clinical outcomes, it is very difficult to modify once pregnant.[1]

A systematic review (22 review articles, 624 studies) reported that maternal obesity significantly increased the incidence of gestational diabetes mellitus (GDM), hypertension, preeclampsia, depression, cesarean delivery, and infection.[10] In addition, the study demonstrated that maternal obesity increased the risk of fetal complications such as preterm birth, congenital anomalies, neonatal macrosomia, and perinatal death.[10] Optimal gestational weight gain should be based on the prepregnancy maternal body mass index to enhance pregnancy outcomes.[11−13]

Surgical complexity for cesarean delivery is present for women with a body mass index >40 kg/m^2 [14−22]: (1) preoperative care (identification of an appropriate operating room table with air mattress, lift device, wheel chair, and toilet; adequate human resource planning [medical and nursing staffing]; abdominal incision planning based on the primary obesity location and the relationship to the position of the uterus/lower uterine segment/fetal position; transverse abdominal wall incision is preferred; abdominal skin/pannus preparation with chlorhexidine wash [day of the scheduled cesarean delivery] and no shaving), (2) intraoperative care (review of plan for pannus management and operative field draping; wound care: intravenous antibiotic prophylaxis with higher dosing; no manual removal of the placenta; intraabdominal uterine closure; closure of subcutaneous layer >2 cm; minimize creation of dead space with surgical technique; consider the use an absorbable suture for skin closure; do not use wound drains), and (3) postoperative care (enhanced postpartum follow up for wound assessment).

New guidelines for the prevention, detection, evaluation, and management of high blood pressure in adults provide guidance for women with preexisting hypertension during pregnancy.[23,24] First-trimester screening for preeclampsia is not considered in this ERAS CD optimization.

Classification of blood pressure in adults requires the following values[25]:

Normal: systolic pressure <120 mm Hg/diastolic pressure <80 mm Hg;

Elevated: systolic pressure range 120−128mm Hg/diastolic pressure <80 mm Hg;

Hypertension: stage 1 systolic 130−139 mm Hg/diastolic 80−89 mm Hg; stage 2 systolic ≥140 mm Hg/diastolic ≥90 mm Hg.

Maternal chronic hypertension is a common comorbidity during pregnancy.[26] A systemic review and meta-analysis (55 studies; 795,221 patients) reported that chronic hypertension significantly increased the incidence of preeclampsia, cesarean section delivery, fetal growth restriction, preterm delivery, neonatal unit admission, and perinatal death.[27] Twenty-five percent of women with chronic hypertension will experience superimposed preeclampsia,[28] which will further increase the risk of the development of serious maternal problems, such as kidney failure, liver failure, abnormalities of the clotting system, and stroke.[29] Preeclampsia (caused by chronic or pregnancy-related hypertension) increases the risk of adverse fetal complications, such as intrauterine growth restriction, low birthweight, preterm delivery, and neonatal respiratory distress syndrome.[30] Appropriate management of maternal chronic hypertension during pregnancy can improve the clinical outcome, reduce the complications, and decrease cesarean delivery rate.[25,30,31]

In pregnancy, the goal of antihypertensive treatment includes the prevention of severe hypertension and the possibility of prolonging gestation to allow the fetus more time to mature before delivery. Treatment of mild-to-moderate hypertension (systolic blood pressure 140−169 mm Hg/diastolic blood pressure 90−109 mm Hg) has reduced the progression to severe hypertension by 50% compared with placebo but has not been shown to prevent preeclampsia, preterm birth, small for gestational age, or infant death. Beta-blockers and calcium channel blockers appear superior to alpha-methyldopa for the prevention of preeclampsia.[31] Women with hypertension who become pregnant should be transitioned to methyldopa, nifedipine, or labetalol during pregnancy.[32] Women with hypertension who become pregnant should not be treated with angiotensin-converting enzyme inhibitors, angiotensin II receptor blockers, or direct renin inhibitors because they are fetotoxic.[31]

The 2013 American College of Obstetricians and Gynecologists (ACOG) Task Force on Hypertension in Pregnancy recommends systolic 120−160 mm Hg/diastolic 80−105 mm Hg for pregnant women with chronic hypertension as the optimal blood pressure target.[24] Blood pressure values of systolic ≥150−160 mm Hg/diastolic ≥100−110 mm Hg should be treated.[24] Drug choice of antihypertensive medications in hypertensive pregnant women is limited to those medications that have been proved relatively safe and that have a long history of clinical use in pregnancy with acceptable side-effects (such as labetalol, nifedipine, methyldopa, and hydralazine).[28,29] There are insufficient

data regarding the best regimen to treat hypertension in pregnancy because of the lack of adequately powered, randomized trials.[29]

Diabetes mellitus during pregnancy comprises both preexisting diabetes mellitus (type 1 or type 2) and GDM that was first diagnosed during pregnancy (typically at 24−28 weeks of gestation after GDM screening).[33−35] Women with preexisting diabetes mellitus or GDM are at an increased risk for maternal and fetal complications (type 1 and 2 GDM).[33−35] Poorly controlled diabetes mellitus in pregnancy increases the risk of spontaneous abortion, fetal anomalies, preeclampsia, fetal death, macrosomia and neonatal hyperglycemia, and/or hyperbilirubinemia.[34−37] A matched control study with 2775 patients reported that untreated GDM carried significant risks for perinatal morbidity and death (stillbirth, neonatal macrosomia, neonatal hypoglycemia, erythrocytosis, and hyperbilirubinemia).[38]

The American Diabetes Association "Management of Diabetes in Pregnancy"[39] and the revised ACOG Practice Bulletin on Gestational Diabetes Mellitus[40] have new recommendations for diabetic management in pregnancy.

There are a variety of glucose challenge test screening tools that are used internationally at 24−28 weeks of gestation.[41] There are 2-step and 1-step protocols recommended, and their use tends to be regional or country directed. The World Health Organization (WHO) and the International Association of the Diabetes and Pregnancy Study Groups (IADPSG) recommend a 1-step screen (with the use of a 75-g glucose load with normal plasma glucose measurements of fasting [92−125 mg/dL]/1 hour [<180 mg/dL]/2 hour [WHO 153−199 mg/dL; IADSPG <153 mg/dL]). The 2-step approach initially uses a primary 50-g glucose load (with no fasting required) with a 1-hour normal plasma glucose of <135 mg/dL. If levels are normal, no further testing is recommended; however, when the plasma glucose is elevated, a 75- or 100-g glucose challenge test is required (American Diabetic Association 75-g load with normal plasma glucose values at fasting [<95 mg/dL]/1 hour [<191 mg/dL]/2 hours [<160 mg/dL]; National Diabetes Data Group 100-g load with normal plasma glucose values at fasting [<105 mg/dL]/1 hour [<190 mg/dL]/2 hours [<165 mg/dL]/3 hours (<145 mg/dL]).[40,41]

The new IADPSG criteria oral glucose tolerance test increases the prevalence of GDM to 19.6% from the Australasian Diabetes in Pregnancy Society oral glucose tolerance test rate of 9.8%.[42]

Glycemic targets in pregnancy (ADA; ACOG)[39,40] are similar for both preexisting diabetes mellitus and GDM (>24−28 weeks of gestation) with fasting and either 1- or 2-hour postprandial testing (preprandial testing for preexisting diabetes mellitus with insulin pumps and basal-bolus therapy is considered): (1) fasting <95 mg/dL (<5.3 mmol/L), (2) 1-hour postprandial <140 mg/dL (<7.8 mmol/L), (3) 2 postprandial <120 mg/dL (<6.7 mmol/L).

Hemoglobin A1C level should only be used as a secondary measure of glycemic control in pregnancy.[39]

GDM management starts with lifestyle management (medical nutrition, physical activity, weight management) with the use of the glycemic targets listed earlier. This approach has a 70−85% success rate for the American Diabetes Association criteria but lower success for the IADPSG criteria.[39]

If unable to meet the glycemic targets, pharmacologic therapy will require the use of medication with insulin as the preferred choice because both metformin (greater transfer/less neonatal hypoglycemia) and glyburide (higher neonatal hypoglycemia and macrosomia) cross the placenta.[39]

A randomized, controlled trial (948 patients) demonstrated that women who were treated for GDM reduced the risks of fetal overgrowth, shoulder dystocia, cesarean delivery, and hypertensive disorders.[43] Another metaanalysis (42 trials) showed that a combination of treatments that start with dietary modification, exercise, glucose monitoring, and pharmacologic treatments reduced the risks of neonatal hypoglycemia, macrosomia, preeclampsia, cesarean delivery, and admission to the neonatal intensive care unit.[44]

Optimization of maternal diabetic glycemic control in pregnant women decreases the risk of preeclampsia, fetal macrosomia, shoulder dystocia, and cesarean delivery.[43]

Multidisciplinary team care can optimize maintenance of euglycemia,[45] but optimal glycemic targets have not been identified by controlled trials.[40]

The WHO has reported that globally 38.2% of pregnant women are anemic with the use of the WHO redefined definition of hemoglobin levels <11.0 g %.[46,47] Iron deficiency anemia accounted for most maternal anemia cases. The National Health Service Blood Transfusion Committee Guidelines supports the use of preoperative screening for maternal anemia.[47] Iron deficiency and any underlying disorder should be identified and corrected by oral supplementation or parenteral intravenous iron if the disorder is unresponsive to oral therapy before any scheduled surgery.[48,49]

Maternal anemia during pregnancy is associated with low neonatal birthweight that affects 25% of newborn infants (adjusted odds ratio, 1.23; 95% confidence interval, 1.06−1.43)[50,51] and preterm birth.[51] Risk of maternal death is associated with severe anemia in pregnancy and the postpartum period (adjusted odds ratio, 2.36; 95% confidence interval, 1.60−3.48; propensity score analysis [conditional probability] adjusted odds ratio, 1.86; 95% confidence interval, 1.39−2.49).[52] There was a linear relationship between maternal anemia and death; with each 10 g/L increase in maternal hemoglobin, there was a 29% reduction in maternal mortality rate (odds ratio, 0.71; 95% confidence interval, 0.60−0.85).[53] In addition, preoperative anemia increased the perioperative morbidity and mortality rates.[54]

Clinical evidence has demonstrated the relationship between smoking and adverse reproductive outcomes.[32,55−58] The United States Surgeon General's report demonstrated that there is a strong association between smoking during pregnancy and fetal growth

restriction/low birthweight, preterm delivery, spontaneous abortion, premature rupture of the membranes, placenta previa, placental abruption, stillbirth, and neonatal mortality rates.[54,55] The effects of nicotine on human fetal development have indicated that in utero exposed children have multisystem effects in endocrine, reproductive, respiratory, cardiovascular, and neurologic systems that include learning disabilities.[59,60]

Summary and recommendations

1. Maternal obesity (body mass index >40 kg/m^2) significantly increases risks of maternal and fetal complications. Optimal gestational weight gain management should be used to control the weight during pregnancy. Surgical complexity requires multidisciplinary planning (Evidence Level: High/Recommendation Grade: Strong).
2. Maternal hypertension should be managed during pregnancy because maternal chronic- and pregnancy-associated hypertension have been found to increase significantly the incidence of maternal and fetal morbidity and cesarean delivery (Evidence Level: High/Recommendation Grade: Strong).
3. Maternal prepregnancy and GDM have been found to increase significantly the risk for maternal and fetal morbidity. Maternal diabetes mellitus should receive timely and effective management during preconception and pregnancy (Evidence Level: High/Recommendation Grade: Strong).
4. Maternal anemia during pregnancy is associated with low birthweight, preterm birth, and increased perioperative morbidity and mortality rates. The cause of the anemia should be identified and corrected (Evidence Level: Moderate/Recommendation Grade: Strong).
5. Maternal cigarette smoking is associated with adverse medical and reproductive morbidity and should be stopped before or in early pregnancy (Evidence Level: Moderate/Recommendation Grade: Strong).

APPENDIX REFERENCES

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APPENDIX TABLE

Summary of maternal and fetal adverse events for maternal obesity body mass index >40 kg/m^2

Odds ratio for adverse maternal outcomes associated with body mass index >35 kg/m^2[a]		Odds ratio for adverse fetal outcomes for maternal obesity[b]	
Adverse outcome	**Odds ratio**	**Fetal outcome**	**Odds ratio**
Gestational diabetes mellitus	4.0 (3.1–5.2)	NTD	1.87 (1.62–2.15)
Gestational hypertension	3.2 (2.6–4.0)	CL/P	1.20 (1.03–1.40)
Preeclampsia	3.3 (2.4–4.5)	Hydrocephalus	1.68 (1.19–2.36)
Operative vaginal delivery	1.7 (1.2–2.2)	Limb reduction	1.34 (91.03–1.73)
Fetal macrosomia >4500 g	2.4 (1.5–3.8)	Cardiac	1.30 (1.12–1.51)
		IUFD	3.90 (2.44–6.22)

CL/P, cleft lip/palate; *IUFD*, intrauterine fetal death; *NTD*, neutral tube defect.

[a] Data from[75]; [b] data from[76]. United States data indicate that 8% of all reproductive age women have a body mass index of >40 kg/m^2.[75] Maternal obesity and associated fetal risks would include congenital anomalies, stillbirth, macrosomia, and long-term implications such as childhood obesity and type II diabetes mellitus. Fetal anomalies will impact the providers, counselling, and planning.[76]

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