INTRODUCTION

Cesarean section delivery is one of the most commonly performed surgical procedures worldwide. It has been deemed an essential surgery in the Disease Control Priorities, 3rd edition, and access to safe cesarean section (along with laparotomy and open fracture management) was identified by the Lancet Commission on Global Surgery as a proxy for a functioning health system able to provide comprehensive, essential surgical care. Having access to safe, emergency cesarean section is also cost-effective for the health system. Yet, in a survey of low- and middle-income countries (LMIC), only 74% of facilities reported performing cesarean section. Of facilities that referred for cesarean section, 53.2% cited lack of skills for performing the procedure, 42.9% cited lack of functioning equipment, and 33.3% cited lack of supplies or drugs as contributing to need for referral. Urgent investment to increase hospital capabilities and capacity to provide safe cesarean section is necessary to reduce maternal morbidity and mortality.

Although cesarean section is often a life-saving intervention for mothers and babies, it can additionally have both short- and long-term maternal and neonatal adverse impacts. Evidence is mounting regarding impacts of cesarean section on neonatal physiology leading to altered immune development, increased risks of allergy, atopy and asthma, as well as greater likelihood of childhood obesity. Compared to vaginal delivery, cesarean delivery increases the risk of severe acute maternal morbidity (SAMM), a composite measure encompassing the following serious maternal risks: hemorrhage requiring hysterectomy or blood transfusion, uterine rupture, anesthetic complications, obstetric shock, cardiac arrest, acute renal failure, need for intubation, venous thromboembolism, major infection, in-hospital wound disruption, and
Cesarean section increases maternal risks in a subsequent pregnancy even if the patient delivers vaginally, including risk of ectopic pregnancy, stillbirth, preterm birth, and SAMM. At the time of repeat cesarean section, history of each prior cesarean section confers incrementally increased risks of requiring hysterectomy, blood transfusion of ≥4 units packed red blood cells, cystotomy, bowel injury, placenta previa, postoperative intubation, prolonged hospital stay, increased operative time, endometritis, and maternal death. In higher-income countries, maternal mortality associated with cesarean section is rare; one retrospective Dutch study found only 0.2 deaths per 1000 cesarean sections. The mortality rate associated with cesarean section in Africa is 50 times greater than in high income settings; a 2019 meta-analysis found 11 women died per 1000 cesarean sections in sub-Saharan Africa, and a prospective study of surgical outcomes in 247 African hospitals found 14% of women who delivered by cesarean section suffered complications, and five women died per 1000 births. It is therefore essential for practitioners to understand evidence-based practices for conducting safe, timely, and appropriate cesarean section, and develop improved decision-making skills to prevent unnecessary cesarean sections.

EPIDEMIOLOGY

Globally, cesarean section rates (the number of cesarean sections divided by the total number of live births) have been steadily increasing, but vary widely by region. Worldwide, the rates nearly tripled from 6.7% in 1990 to 19.1% in 2014. As of 2014, cesarean section rates ranged from 3.0% of births in Western Africa to 42.9% of births in Southern America, and from 6% in the least developed regions (grouped according to United Nations criteria) to 27.2% in more developed regions. Cesarean section rates have been found to be decreasing or remaining steady in only three countries (Guinea, Nigeria, and Zimbabwe) between 1990 and 2014; the remainder of countries saw average annual rates of increase of 5% in least developed regions and 2.6% in more developed regions. This increase has been attributed to both an increase in institutional deliveries globally, as well as increased utilization of cesarean section within health institutions. Although a systematic review of ecological studies showed improvements in maternal, neonatal, and infant mortality with increasing access to cesarean section up to a population-level threshold cesarean section rate of 9–16%, the World Health Organization (WHO) has concluded that no improvements in maternal and neonatal mortality are seen when population-level cesarean section rates exceed 10% if controlling for socioeconomic factors. Estimates from 2015 showed that 106 out of 169 countries assessed (63%) had cesarean section rates above 15%, reflective of likely cesarean section overuse, while 48 (28%) of countries had cesarean section rates below 10%, suggestive of poor access to cesarean section. Subnational and socioeconomic disparities in cesarean section rates also exist within countries with higher cesarean section rates seen in urban areas, private facilities, and amongst women in higher wealth quintiles. WHO emphasizes that cesarean section rates may vary depending on facility type, but advocates that cesarean section be reserved for those with appropriate medical indications. WHO recommends using the Robson classification system for monitoring, evaluation, and comparison of cesarean section rates within and between healthcare facilities over time (Table 1).

Table 1  Robson classification system for cesarean section. Adapted from Robson et al. 2013.
Group 7  All multiparous singleton breech presentations (including prior cesarean section)
Group 8  All multiple pregnancies, including with prior cesarean section
Group 9  All women with a singleton with a transverse or oblique lie, including with prior cesarean section
Group 10 All women with a singleton, cephalic presentation, <37 weeks, including prior cesarean section

In low resource areas, particularly rural Sub-Saharan Africa, non-physician clinicians or associate clinicians may primarily perform cesarean section to improve surgical coverage in areas lacking surgical specialists.\textsuperscript{18} Though training varies by country, these providers typically have a lower entry level of education compared to physicians and shorter pre-service education;\textsuperscript{18} however, associate clinicians are much more likely to stay and practice in rural areas with approximately 90% retention compared to physicians. In some rural government district hospitals, associate clinicians may perform up to 90% of the major obstetric surgeries, particularly in Ethiopia, Tanzania, Mozambique, and Malawi.\textsuperscript{19} Although most studies show that compared to physician-performed cesarean section, associate clinician-performed cesarean section resulted in similar rates of neonatal death, surgical site infection (SSI), and maternal mortality,\textsuperscript{19} a study in Sierra Leone did show associate clinician-performed cesarean section were associated with increased re-admissions (odds ratio (OR) 2.17, 95% confidence interval (CI) 1.08–4.42).\textsuperscript{20} Training associate clinicians in comprehensive obstetric and neonatal emergency care in rural Tanzanian health facilities led to an increase in cesarean section provision (1–22/month from a baseline of 0), 300% increase in institutional deliveries, and a reduction in obstetric referrals (OR 0.2, 95% CI 0.1–0.4).\textsuperscript{21} However, associate clinicians remain underutilized due to academic center resistance and lack of institutional training to use them for task-shifting.\textsuperscript{19}

INDICATIONS

Indications for cesarean section include both maternal and fetal indications. Emergent maternal and fetal indications include cord prolapse, fetal prolonged terminal bradycardia, massive antenatal hemorrhage, uterine rupture, and perimortem cesarean section for suspected imminent maternal demise. Non-emergent fetal indications include fetal distress, fetal malpresentation (especially transverse lie), multifetal gestation (twin gestation with non-cephalic presenting twin, monochorionic monoamniotic twin gestation or higher order multifetal birth), and concern for fetal macrosomia (estimated fetal weight >4.5 kg if diabetic mother or >5 kg if no maternal diabetes).\textsuperscript{22} Non-emergent maternal indications include history of three or more prior low-transverse cesarean section; prior uterine scar extending into the contractile myometrial layer including certain prior cesarean section incisions (e.g., classical, inverted T, J, or mid-segment), history of myomectomy with extensive myometrial involvement, or history of prior uterine rupture; complete placenta previa; placenta accreta spectrum (PAS) (i.e. placenta accreta, increta, or percreta); active maternal herpes infection or HIV with elevated viral load; maternal bulky carcinoma, condyloma, or fibroid which blocks the pelvic outlet or vaginal canal; obstructed labor; and pre-eclampsia or eclampsia remote from delivery. Women with prior shoulder dystocia, history of third- or fourth-degree laceration, and history of inflammatory bowel disease with active perianal disease or prior ileal pouch-anal anastomosis can be offered planned cesarean section. Women with a history of prior low-transverse cesarean section may elect to undergo planned repeat cesarean section, but should be informed of the risks and benefits of trial of labor after a prior cesarean section.

Obstructed or prolonged labor is a common indication for cesarean section. As of 2014, the American College of Obstetricians and Gynecologists (ACOG) recommends considering 6 cm dilation the start of the active phase of labor and defines arrest of the first stage of labor as no cervical change in the active phase of labor for over 4 hours despite adequate contractions or for over 6 hours of labor with inadequate contractions despite oxytocin augmentation.\textsuperscript{22} ACOG additionally advises allowing at least 2 hours of pushing in the second stage for multiparous patients and 3 hours of pushing for nulliparous patients prior to diagnosing an arrest of second stage of labor, and considering longer durations in the setting of epidural use or fetal malposition so long as ongoing progress is documented.\textsuperscript{22} In the second stage of labor, pending appropriate circumstances, operative vaginal delivery may be performed in lieu of cesarean section to expedite delivery if trained providers are available.\textsuperscript{22} Please see other chapters within this series for further information.
Breech singleton presentation is not necessarily an absolute medical indication for cesarean section. A large multicenter randomized clinical trial published in 2000 initially showed significant reduction in the composite outcome of perinatal mortality, neonatal mortality, or serious neonatal morbidity with planned cesarean section versus planned vaginal delivery (relative risk (RR) 0.33, 95% CI 0.19–0.56), but follow up studies at 2 years failed to show differences in death or neurodevelopmental delay for children in the two groups or significant differences in maternal morbidity. A 2015 Cochrane systematic review including these and several other trials showed planned cesarean section led to reductions in perinatal or neonatal death (RR 0.29, 95% CI 0.10–0.86, three studies), no significant difference in brachial plexus injury, increased short-term maternal morbidity (RR 1.29, 95% CI 1.03–1.61, three studies), decreased maternal urinary incontinence at 3 months (RR 0.62, 95% CI 0.41–0.93, one study), increased maternal abdominal pain at 3 months (RR 1.89, 95% CI 1.29–2.79, one study), no differences in death or neurodevelopmental delay in children at 2 years, but increased rate of children with medical conditions at 2 years (RR 1.41, 95% CI 1.05–1.89, one study). A trial of external cephalic version (ECV) at 34–35 weeks' gestational age has been associated with decreased breech vaginal delivery and decreased non-cephalic presentation at birth, but increased risk of late preterm delivery. In light of these studies, medical societies including ACOG, the French College of Gynecologists and Obstetricians (CNGOF) and the Royal College of Obstetricians and Gynaecologists (RCOG) endorse offering patients ECV if there is no contraindication to vaginal delivery and if there is immediate availability to perform emergency cesarean section if required. Recommendations for timing of ECV vary by society: CNGOF recommends ECV at 36 weeks, RCOG recommends ECV at 37 weeks for multiparous patients and 36 weeks for nulliparous patients, and ACOG recommends ECV at 37 weeks. Patients with persistent singleton breech presentation at term can be offered scheduled cesarean section given the reduced perinatal mortality and neonatal morbidity. ACOG and CNGOF advise that planned vaginal delivery of the singleton breech term fetus may be reasonable pending patient desire, provider experience, and facility protocol. This may be especially relevant in areas where there is significantly higher maternal morbidity/mortality associated with cesarean section.

EVIDENCE-BASED PRACTICES

The remainder of this chapter focuses on evidence-based best practices for cesarean section which can be incorporated into training protocols. There has been increasing research related to the implementation of specific preoperative, intraoperative, and postoperative considerations for cesarean section and the design of intervention bundles aimed to improve outcomes including reducing the risk of postoperative SSI, enhancing recovery after surgery, and decreasing postoperative length of stay. The evidence for these practices is summarized below; the corresponding recommendations from various societies are discussed below when applicable and outlined in Table 3 below. Several society guidelines use the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach for making recommendations which accounts for the quality of the evidence reviewed and the strength of the recommendation (Table 2).

Table 2  Grading of Recommendations Assessment, Development, and Evaluation (GRADE) system for rating quality of evidence and strength of recommendations scale. Adapted from Guyatt et al. 2008.

<table>
<thead>
<tr>
<th>Quality of evidence rating</th>
<th>Definition</th>
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<tbody>
<tr>
<td>High quality</td>
<td>Further research is very unlikely to change confidence in the estimate of effect</td>
</tr>
<tr>
<td>Moderate quality</td>
<td>Further research is likely to have an important impact on confidence in the estimate of effect and may change the estimate</td>
</tr>
<tr>
<td>Low quality</td>
<td>Further research is very likely to have an important impact on confidence in the estimate of the effect and is likely to change the estimate</td>
</tr>
<tr>
<td>Very low quality</td>
<td>Any estimate of the effect is very uncertain</td>
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<td>Strength of</td>
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### PRE-OPERATIVE CONSIDERATIONS

**Gestational age timing of planned cesarean section**

ACOG and the UK National Institute for Health and Care Excellence (NICE) recommend that planned cesarean section be performed after 39 weeks gestational age unless earlier delivery is otherwise medically indicated. This is due to improved neonatal outcomes with delivery after 39 weeks: in one systematic review, risk of neonatal respiratory morbidity, hypothermia, hypoglycemia, neonatal intensive care unit admissions, and neonatal mortality were found to be worse in infants delivered by cesarean section prior to 39 weeks of gestation. Additionally, risk of neonatal mortality increases again with cesarean section delivery performed after 39+6 weeks gestation.

**Cesarean section skills and team training**

Consideration should be given to incorporating cesarean section knowledge and skills-training curricula including:

1. Personnel-training on evidence-based intraoperative techniques;
2. Team-based training (physicians, nurses, nursing assistants, anesthesia team, neonatology or pediatric personnel) and simulation of emergencies which may be encountered during cesarean section; and
3. Team-based training and simulation on implementing evidence-based cesarean section bundles.

No study specifically examines the impact of cesarean section skills training on patient outcomes, but there have been multiple studies on scenario-based simulation training for obstetric emergencies, which have been shown to result in significant improvements in patient outcomes even in lower resource settings. Emergency obstetric training in South Africa resulted in 29% reduction in maternal deaths (RR 0.71, 95% CI 0.66–0.77); postpartum hemorrhage training in Tanzania resulted in 47% decrease in rates of whole blood transfusion. On a hospital level, simulation and team-based training have also been shown to increase adherence to evidence-based practices. Educational posters and talks on surgical site infection (SSI) prevention resulted in increased use of prophylactic antibiotics (from 54% to 68%) in a tertiary care setting. A meta-analysis on the impact of cesarean section bundles on SSI found that 8/14 studies included provider and/or patient education in implementing their cesarean section bundle. Team training may additionally improve team communication during surgery.

**Surgical huddle and surgical safety checklist**

Performing a surgical team huddle with use of a surgical safety checklist prior to the start of a cesarean section is recommended by WHO to ensure systematic adherence to safe surgery practices. Surgical safety checklist use has been shown to improve surgical outcomes and quality, leading to reduced perioperative mortality and increased adherence to preoperative antibiotic administration (56.1% to 82.6%, p <0.001). As part of the pre-procedure huddle, surgeons can communicate urgency of the cesarean section to nursing, anesthesia, and pediatric staff using classification guidelines; for example, NICE recommends using the following categories when communicating the timing of cesarean section:

1. Immediate threat to the life of the women or fetus (perform delivery as soon as possible, at least within 30 minutes of decision);
2. Maternal or fetal compromise which is not immediately life-threatening (perform delivery as soon as possible, but goal at
least within 75 minutes of decision);  
3. No maternal or fetal compromise;  
4. Delivery timed to suit staff or patient needs.

For an emergent, category 1 cesarean section, it may be prudent to modify the pre-procedure huddle and develop a shortened emergency huddle to expedite surgery.

The WHO Surgical Safety Checklist comprises 16 steps, divided into three time periods: (1) before induction of anesthesia, (2) before skin incision, and (3) before patient leaves the operating room. Prior to anesthetic induction, at least the nurse and anesthetist should confirm the patient's identity, the procedure to be performed, and that consent has been obtained; the site has been marked if applicable; the anesthesia machine and medications have been checked; the pulse oximeter has been placed on the patient and has been confirmed to be functioning; patient allergies have been confirmed; patient's airway has been evaluated; and placement of two large-bore IVs has been performed if anticipated blood loss is greater than 500 mL. Prior to skin incision, the nurse, anesthetist, and surgeon should confirm their names and team roles, the patient's identity, procedure to be performed, and location of incision; appropriate antibiotic prophylaxis has been given in the last 60 minutes; any specific nursing-, surgical-, or anesthesia-related concerns or anticipated critical steps have been identified; availability of appropriate equipment; and sterility has been confirmed. The checklist additionally contains provisions for a postoperative debriefing including confirmation of the procedure actually performed, specimen labeling, and any anticipated concerns for patient recovery. This surgical safety checklist can be feasibly performed and recorded during cesarean section even in low-resource settings such as Tanzania.

Preoperative fasting

The Enhanced Recovery After Surgery Society (ERAS) and the Society for Obstetric Anesthesia and Perinatology (SOAP) endorse encouraging clear fluids up to 2 hours prior to cesarean section and a light meal up to 6 hours prior to surgery, but recommend waiting 8 hours or more to perform cesarean section after heavy meals including fried or fatty foods. ERAS and SOAP also suggest offering non-diabetic women an oral carbohydrate fluid supplementation 2 hours prior to scheduled cesarean section; several small randomized controlled trials have shown improvements in subjective patient well-being and breastfeeding outcomes (earlier breastfeeding initiation, improved breastfeeding frequency and length of feeds) among patients randomized to preoperative oral high-carbohydrate fluid supplementation versus low-carbohydrate oral rehydration solution or water, respectively.

Anesthetic choice

NICE and ERAS recommend neuraxial anesthesia (e.g., epidural, spinal) for planned cesarean section if no maternal contraindication given the increased risk of complications with general anesthesia. In low- and middle-income countries, exposure to general anesthesia compared to neuraxial anesthesia increased the odds of maternal mortality (OR 3.3, 95% CI 1.2–9.0) and perinatal mortality (OR 2.3, 95% CI 1.2–4.1).

Pre-anesthetic medications

NICE and ERAS recommend administering histamine type-2 (H2) receptor blockers and antacids to reduce the risk of aspiration pneumonitis, which in rare instances can cause maternal death. Antacids like sodium citrate neutralize gastric acid, while H2 receptor blockers such as ranitidine inhibit gastric acid secretion and reduce both volume and acidity of stomach contents. In a 2014 Cochrane of 22 low-quality trials of cesarean section under general anesthesia, antacids plus H2 blockers showed significantly reduced risk of acidic intragastric pH at intubation compared to placebo (RR 0.02, 95% CI 0.00–0.15) and compared to antacids alone (RR 0.12, 95% CI 0.02–0.92). ERAS guidelines recommend use of fluid-preloading and, in cases of neuraxial anesthesia, IV-administration of ephedrine or...
phenylephrine and lower limb compression to avoid maternal post-spinal hypotension, but a 2020 Cochrane Review showed these interventions did not improve maternal nausea and vomiting. Use of ondansetron compared to placebo was the only intervention shown to improve maternal hypotension (RR 0.67, 95% CI 0.54–0.83, 8 studies, low-quality evidence) as well as postoperative nausea and vomiting (average RR 0.35, 95% CI 0.24–0.51, 7 studies, low-quality evidence). Ondansetron is a potent anti-emetic and also reduces risk of hypotension and bradycardia after spinal anesthesia due to blunting of the Bezold-Jarisch reflex.

Preoperative antibiotics

Preoperative antibiotics should be administered within 30–60 minutes before cesarean section skin incision to reduce the risk of SSI. The 2014 Cochrane systematic review showed reduced incidence of cesarean section-associated febrile morbidity with administration of preoperative antibiotic prophylaxis (RR 0.45, 95% CI 0.39–0.51) including decreased rates of wound infection (RR 0.39, 95% CI 0.32–0.48), endometritis (RR 0.38, 95% CI 0.34–0.42), and serious maternal infectious complications (RR 0.31, 95% CI 0.19–0.48). Prophylactic antibiotics should be administered prior to skin incision as this decreases the risk of SSI compared to administration after umbilical cord-clamping (RR 0.59, 95% CI 0.44–0.81, 10 trials, high certainty evidence). Patients undergoing pre-labor cesarean section should receive a first-generation cephalosporin such as cefazolin, and those who have labored or have rupture of membranes prior to cesarean section should also receive adjunctive azithromycin, which was shown to reduce post-cesarean section infectious morbidity (RR 0.51, 95% CI 0.38–0.68) in this subgroup. Standard dosing for cefazolin in pregnancy should be 2 g IV, with consideration for 3 g IV administration in morbidly obese women, especially those with body mass index (BMI) ≥40 kg/m². Cefazolin should be re-dosed for prolonged surgery or significant blood loss. ACOG recommends redosing cefazolin after 4 hours (e.g. procedure greater than 2 half-lives of the antibiotic) or after 1500 mL of blood loss, though there is some evidence to suggest redosing cefazolin after 3 hours given the different pharmacokinetics in pregnant women. For patients with penicillin allergies, clindamycin and an aminoglycoside, typically gentamicin, should be administered preoperatively.

Preoperative bathing

WHO and the Centers for Disease Control and Prevention (CDC) recommend patients bathe or shower preoperatively either the night prior to surgery or on the day of surgery. Either plain soap or antimicrobial soap may be used. According to a WHO evidence review, preoperative bathing with chlorhexidine gluconate (CHG) soap does not significantly reduce SSI rates compared to bathing with plan soap (OR 0.92, 95% CI 0.80-1.04). There is insufficient evidence to support use of preoperative CHG soap or CHG-impregnated cloths for the purposes of reducing SSI; thus, use of CHG-impregnated cloths may be prohibitively costly without associated benefit particularly in low-resource settings.

Hair removal

WHO and NICE recommend that routine hair removal should not be performed. If hair removal is deemed necessary to obtain appropriate surgical exposure, hair should be clipped as this has been shown to have a significantly lower risk of SSI compared to shaving with razors (OR 0.51, 95% CI 0.34–0.78).

Abdominal skin preparation

WHO and the CDC recommend applying an alcohol-based CHG solution prior to incision and allowing the skin to dry for 3 minutes prior to draping. CHG has been found to be superior to povidone-iodine for preventing SSI after clean-contaminated surgery and cesarean section (RR 0.59, 95% CI 0.41–0.85) and (RR 0.72, 95% CI 0.52–0.98), respectively. CHG can be locally produced in African Hospitals and is cost-effective given the reduction in SSI.

Vaginal preparation
Vaginal preparation with 10% povidone-iodine or CHG solution with low-alcohol content prior to all unscheduled cesarean section and planned cesarean section should be considered. A 2020 Cochrane systematic review showed improved outcomes with antiseptic vaginal preparation versus placebo: cleansing with 10% povidone-iodine or CHG solution prior to cesarean section reduced the risk of post-section endometritis (3.4% vs. 7.2%, average risk ratio (aRR) 0.41, 95% CI 0.29–0.58, 20 trials, 6918 women), postoperative fever (aRR 0.64, 95% CI 0.50–0.82, 16 trials, 6163 women), and postoperative wound infection (aRR 0.62, 95% CI 0.50–0.77, 18 trials, 6385 women), especially after unscheduled laboring cesarean section or rupture of membranes prior to cesarean section. Both povidone-iodine and CHG solution with low-alcohol content were safe for vaginal cleansing without adverse effects being reported. Recent ERAS guidelines recommend considering vaginal preparation with povidone-iodine for all cesarean section, but these were published prior to the 2020 Cochrane systematic review showing safety and efficacy of chlorhexidine. As of yet, there have not been any head to head comparisons of povidone-iodine versus CHG solution for vaginal preparation prior to cesarean section.

**Indwelling urinary catheter placement**

NICE recommends indwelling urinary catheter placement in all patients undergoing cesarean section under neuraxial anesthesia given the associated urinary retention, but recommends removal at 12 hours. ERAS guidelines suggest removal of the urinary catheter immediately after cesarean section if one was placed during surgery. There is a dearth of high-quality, large-scale evidence regarding indwelling urinary catheter placement at the time of cesarean section and placement has not been associated with reduction in bladder injury. However, presence of an indwelling catheter may assist in intraoperative and expeditious recognition of a bladder injury if one occurs, as is discussed below. The 2014 Cochrane review included only five randomized controlled trials which included 1065 women. Compared to no catheterization, placement of an indwelling urinary catheter at time of cesarean section was associated with reduced incidence of bladder distention (RR 0.02, 95% CI 0.00–0.35; 1 study, 420 women), reduced postoperative urinary retention (RR 0.06, 95% CI 0.01–0.47, 2 studies, 420 women), and reduced need for postoperative catheterization (RR 0.03, 95% CI 0.01–0.16, 3 studies, 840 women), but was associated with increased time to first spontaneous void (mean difference (MD) 16.8 hours, 95% CI 16.3–17.3 hours, 1 study, 420 women), longer time to ambulation (MD 4.3 hours, 95% CI 1.37–7.31 hours, 3 studies, 840 women), longer hospital stay (MD 0.62 days, 95% CI 0.15–1.10, 3 studies, 840 women), and more postoperative discomfort (RR 10.47, 95% CI 4.71 to 23.25, 2 studies, 420 women). A 2013 systematic review examining the evidence-base for cesarean section steps therefore recommended considering omitting catheter placement or ensuring early catheter removal.

**Maintaining normal body temperature**

WHO suggests the use of warming devices to maintain normothermia, while ERAS and SOAP guidelines additionally endorse IV fluid warming for the prevention of maternal hypothermia during cesarean section, as this has been associated with increased risk of SSI. Active use of forced-air warming devices or IV fluid warming have also been shown in a meta-analysis to improve intraoperative shivering, improve maternal thermal comfort, decrease hypothermia, and possibly improve neonatal umbilical artery pH at delivery.

**INTRAOPERATIVE TECHNIQUES AND OTHER CONSIDERATIONS**

**Skin incision**

Either the Joel-Cohen or Pfannenstiel skin incision and abdominal entry technique are recommended, although there is evidence that the Joel-Cohen incision and entry technique may offer improved patient outcomes. A vertical midline incision may be reserved for patients with prior extensive history of abdominal surgery, for situations where concomitant cesarean section hysterectomy is planned or is anticipated, for cesarean section performed under local anesthesia, or for other situations where improved intra-abdominal access is required. Compared with a low transverse abdominal incision, a vertical midline incision is associated with worse cosmesis and increased risk of wound dehiscence and postoperative incisional hernia. Traditionally, the Joel-Cohen technique involves a straight, transverse incision 3 cm
below the line connecting the anterior superior iliac spines with dissection of the subcutaneous tissue for only 2–3 cm in the midline, blunt expansion of the fascia after incising the fascia transversely in the midline, and blunt separation of the rectus muscles in the midline, while the Pfannenstiel entry involves a curvilinear skin incision 2–3 cm above the pubic symphysis with sharp dissection of the subcutaneous tissues, sharp expansion of fascial incision, and blunt and sharp dissection of rectus muscles off the overlying fascia. The Joel-Cohen technique compared with Pfannenstiel technique is associated with decreased blood loss (MD minus 58.0 mL, 95% CI minus 108.5–minus 7.5 mL), shorter operative time (MD minus 11.4 minutes, 95% CI minus 16.55–minus 6.3 minutes), reduced postoperative analgesic requirements (RR 0.55, 95% CI 0.40–0.76), shorter postoperative maternal hospital stay (MD minus 1.5 days, 95% CI minus 2.16–minus 0.84 days), and reduced postoperative fever (RR 0.35, 95% CI 0.14–0.87) in the 2014 Cochrane review. A 2009 meta-analysis of 14 studies showed similar results: decreased blood loss (MD minus 64.4 mL, 95% CI minus 91.3–minus 37.6 mL); operative time (MD minus 18.6 minutes, 95% CI minus 24.8–minus 12.5 minutes); and fever (RR 0.47, 95% CI 0.28–0.81). In a prospective cohort study, the Joel-Cohen blunt extension of the fascia and blunt entry into the peritoneum was successful in 80% of women who had undergone one prior cesarean section and 65.6% of women with multiple prior cesarean section. However, it is unclear if these data reflect differences in the actual placement of the skin incision or differences in the dissection and entry techniques traditionally associated with them. Regardless, NICE guidelines support use of the Joel-Cohen incision.

Although there is insufficient evidence to support the optimal skin incision for patients with morbid obesity, vertical skin incisions traditionally have been recommended given theoretical concern for increased SSI risk if an infra-pannicular, low-transverse incision were performed. However, compared to infra-pannicular transverse incisions, data show that vertical midline incisions in this population may be associated with increased intraoperative bleeding, increased risk of classical cesarean hysterotomy, increased wound complications, and greater postoperative respiratory compromise. Several types of supra-pannicular transverse incisions have been described for the morbidly obese patient, but there is insufficient evidence to routinely support these approaches. Therefore, low-transverse incision should be considered even in the obese patient.

**Bladder flap**

There is insufficient evidence to recommend for or against the routine creation of a bladder flap prior to making the uterine incision. Evidence suggests that bladder flap creation can lead to increased postoperative urinary retention and worsened postoperative urinary symptoms, and increased incision to delivery time. Randomized controlled trials and meta-analyses have shown no differences in bladder injury with or without development of the bladder flap. One randomized controlled trial (n = 258) showed a decrease in median time to hysterotomy in the non-bladder flap group (9 vs. 10 minutes, p = 0.04) with no differences in other perioperative outcomes (e.g., total operative time, blood loss, pain, UTI, endometritis, or bladder injury). A meta-analysis including this trial and two others also showed a small, but significantly decreased skin incision to delivery time (MD 1.27 minutes, 95% CI 0.63–1.92 min), but no significant difference in total operative time (MD 3.5 minutes, 95% CI minus 0.19–7.16 min). However, only 20% of the patients in the aforementioned trial underwent cesarean section for failure to progress, and three of the four studies in the meta-analysis excluded patients undergoing emergency cesarean section. Additionally, as urologic injury at time of cesarean section is a rare outcome, the data currently available would be underpowered to detect this difference, if one exists. A 2013 systematic review evaluating the evidence base for specific cesarean section steps concluded that routine creation of a bladder flap should be discouraged. However, in settings where cesarean section is performed for failure of descent where the bladder may be adhered theoretically higher on the lower uterine segment, the surgeon may be less likely to incise into the bladder when making the hysterotomy if a bladder flap is first created.

**Hysterotomy site and type**

Transverse incision in the lower uterine segment should be routinely performed if possible. Other incisions such as a low vertical, mid-segment, or classical incision within the contractile portion of the uterus should be reserved for special circumstances such as preterm delivery without well-developed lower uterine segment; fetal transverse, back down presentation; or concern for placenta accreta spectrum, particularly if cesarean section hysterectomy is planned. If fetal
extraction at the time of delivery is quite difficult, it may be necessary to extend the lateral corner of the transverse hysterotomy upwards in a J fashion or the midline of the transverse hysterotomy incision in an inverted-T fashion. All extensions or incisions extending into the contractile portion of the myometrium are associated with increased risk for uterine rupture at the time of subsequent pregnancy, and women should be counseled on need for future cesarean section for delivery.83

For cesarean section performed in the setting of failure to progress, the labored lower uterine segment may be thinner, and choosing a hysterotomy site that is higher in the lower uterine segment may prevent unintended hysterotomy extensions and bladder injury. In one recent trial, performing cesarean section in the second stage of labor conferred ten-fold increased odds of hysterotomy extension (OR 10.2, 95% CI 2.6–39.8), and was the only independent predictor for hysterotomy extension.97 A case–control study found a transverse incision in the upper part of the lower uterine segment demonstrated decreased blood loss (MD 198 mL, 95% CI 137.9–258.1 mL versus 330.1 mL, 95% CI 261.6–398.6 mL; \( p < 0.05 \)), reduced operation time (MD 30.5 minutes, 95% CI 23.9–37.1 minutes versus 45.3 minutes, 95% CI 38.1–52.5; \( p < 0.05 \)), and fewer torn incisions (0 versus 8; \( p < 0.05 \)) compared to the traditional lower uterine segment incision.98

Hysterotomy extension

NICE31 and ERAS36 recommend that the hysterotomy be extended bluntly in the cephalad–caudad direction.33 A meta-analysis of six randomized controlled trials comparing blunt versus sharp expansion of the hysterotomy favored blunt expansion given significantly lower rates of unintended hysterotomy extension (pooled RR 0.47, 95% CI 0.28–0.79), lower drop in postoperative hemoglobin (weighted mean difference (WMD) minus 0.64 mg/dL, 95% CI minus 0.95–minus 0.33 mg/dL), and shorter operative time (WMD minus 2.06 minutes, 95% CI minus 2.11–minus 2.01 minutes).99 There were no significant differences in need for blood transfusion or estimated blood loss, although there was a trend towards decreased blood loss in the blunt expansion groups (WMD minus 88.0 mL, 95% CI minus 184.3–plus 8.1 mL).99 A 2014 Cochrane Review did, however, show significantly decreased blood loss (WMD minus 55.00 mL, 95% CI minus 79.48–minus 30.52 mL) and need for blood transfusion (RR 0.24, 95% CI 0.09–0.62) after blunt expansion of the hysterotomy.100 Neither study showed significant difference in febrile morbidity comparing the two techniques.99,100 A meta-analysis of two randomized controlled trials comparing blunt dissection in the transverse direction versus the cephalad–caudad direction showed significantly fewer unintended hysterotomy extensions (4.8% vs. 8.9%, RR 0.51, 95% CI 0.30–0.88), injuries to the uterine vessels (1.5% vs. 2.8%; RR 0.52, 95% CI 0.20–0.84), and women experiencing significant blood loss (>1500 mL) (0.2% vs. 1.7%, RR 0.12, 95% CI 0.02–0.99) in the cephalad–caudad group.101

Delivery of the placenta

WHO102 and NICE31 recommend delivery of the placenta using gentle cord traction. Compared with cord traction, manual placental removal has been found to increase rates of endometritis (RR 1.64, 95% CI 1.42–1.90), blood loss at time of delivery (plus 94.4 mL, 95% CI plus 17.2–plus 171.6 mL), and duration of hospital stay (plus 0.39 days, 95% CI plus 0.17–plus 0.61 days).103

Exteriorization of the uterus

There is insufficient evidence to definitively recommend for or against routine exteriorization of the uterus, as no significant differences in intra- or postoperative complications have been described;33,104 however, NICE recommends intraperitoneal repair of the uterus at time of cesarean section.31 Exteriorization is often preferred for improved visualization of the surgical field, and in situ repair may be associated with small increases in intraoperative blood loss without a concomitant increased need for blood transfusion, though data are conflicting.105,106 However, surgeons should be aware that exteriorization may increase intraoperative pain, increase vagal response, and worsen intraoperative and postoperative nausea and vomiting, especially in women under neuraxial anesthesia.107,108,109,110

Closure of hysterotomy
NICE\textsuperscript{31} and ERAS\textsuperscript{36} recommend double-layer closure of the hysterotomy (unless the patient desires no future fertility), without further guidance on the type of closure (e.g., continuous, interrupted, locking, non-locking) for each layer.\textsuperscript{31,36} A 2014 Cochrane review found no differences in short-term outcomes (postoperative febrile morbidity, need for blood transfusion, wound infection, postoperative anemia, postoperative pain, death or serious maternal morbidity) between single-layer and double-layer closure of the hysterotomy.\textsuperscript{100} A 2011 meta-analysis found single layer, continuous, locked closure compared with a double layer closure (variably performed) resulted in a higher risk of uterine rupture (OR 4.96, 95\% CI 2.58–9.52), but single-layer, unlocked closure was not associated with a higher risk of uterine rupture compared with double-layer closure (OR 0.49; 95\% CI 0.17–0.61), and decreased risk of scar dehiscence on subsequent deliveries that required cesarean section with or without a trial of labor (trial of labor: 3.2 vs. 10.7\%, \(p<0.001\); no labor: 1.6 vs. 4.0\%, \(p = 0.046\)).\textsuperscript{112} Based on one small randomized controlled trial, there is sonographic evidence of possible better myometrial healing when the first layer of a double-layer closure is not locked, but further large-scale studies are needed to confirm that this specific technique is superior.\textsuperscript{113}

A large, international 2x2x2x2x2 fractional, factorial randomized controlled trial (CORONIS trial) compared five cesarean section elements: blunt versus sharp abdominal entry; exteriorization of the uterus for repair versus intra-abdominal repair; single-layer versus double-layer closure of the uterus; closure versus non-closure of the peritoneum (pelvic and parietal); and chromic catgut versus polyglactin-910 for uterine repair. This trial showed no difference in composite outcome of major maternal morbidity, febrile morbidity, postoperative pain, need for further intraoperative procedures, intraoperative time, or need for blood transfusion for single-layer closure versus double-layer closure of the hysterotomy (RR 0.96, 95\% CI 0.85–1.08).\textsuperscript{114} For women with a subsequent viable pregnancy who had participated in the CORONIS trial, there were no significant differences in rates of uterine rupture, uterine scar dehiscence, placenta previa, morbidly adherent placenta, abruptio, or clinically significant postpartum hemorrhage between women in the single-versus double-layer uterine closure arms at 3-years follow-up.\textsuperscript{115} The CORONIS trial did show that use of chromic catgut for hysterotomy closure may decrease risk of blood transfusion compared with use of polygactin-900 (1.3\% vs. 0.7\%, RR 0.53, 95\% CI 0.30–0.93), but no other significant differences in short-term outcomes were seen for the suture-type comparison.\textsuperscript{114}

**Intraperitoneal irrigation**

SOAP guidelines recommend that intraperitoneal irrigation should be avoided.\textsuperscript{56} Intraperitoneal irrigation has been shown to increase intraoperative nausea (RR 1.68, 95\% CI 1.36–2.06) and vomiting (RR 1.70, 95\% CI 1.28–2.25) without improvements in return of gastrointestinal function, postpartum endometritis, or wound infection rates.\textsuperscript{33,116,117}

**Peritoneum closure**

NICE\textsuperscript{31} and ERAS\textsuperscript{36} recommend against routine closure of the peritoneum. Traditionally, closure of the visceral and parietal peritoneum was described, but evidence suggests that this only increases operative time without benefit. The latest 2014 Cochrane Review included 21 trials and found that non-closure of the peritoneum was associated with reduced operative time (MD minus 5.81 minutes, 95\% CI minus 7.68–minus 3.93 minutes, 16 trials, 15,480 women), reduced length of hospital stay (MD minus 0.26 days, 95\% CI minus 0.47–minus 0.05 days, 13 trials, 14,906 women), and reduced postoperative pain (RR 0.49, 95\% CI 0.25–0.98, 1 trial, 112 women), without an increase in postoperative adhesions or in postoperative febrile morbidity.\textsuperscript{118} There were no differences in the CORONIS trial for the composite primary maternal outcome when comparing non-closure of the peritoneum versus closure of both the parietal and visceral peritoneum.\textsuperscript{114} At the 3-year follow-up of the CORONIS trial, there were no differences in pelvic pain, dyspareunia, infertility, or ectopic pregnancy in the peritoneal closure versus non-closure arms.\textsuperscript{115}

**Subcutaneous tissue closure**

NICE\textsuperscript{31} and ERAS\textsuperscript{36} recommend closure of the subcutaneous tissue if it is \(\geq 2\) cm in depth. A meta-analysis found a decrease in wound disruption with subcutaneous closure (RR 0.66, 95\% CI 0.48–0.91) in women with subcutaneous tissue
With other evidence-based techniques (chlorhexidine skin antisepsis, prophylactic antibiotics), this practice has also been found to lower the risk of wound complications including SSI and cellulitis development, seroma formation, hematoma formation, and wound separation (RR 0.75, 95% CI 0.58–0.95).\textsuperscript{38}

**Subcutaneous drain placement**

NICE recommends against routine placement of subcutaneous drains at the time of cesarean section.\textsuperscript{31} Placement of these superficial wound drains has not been found to be associated with decreased wound complication regardless of subcutaneous tissue thickness.\textsuperscript{33,36,117,120}

**Skin closure**

NICE\textsuperscript{72} and ERAS\textsuperscript{36} recommend skin closure with subcuticular suture instead of staple closure given evidence of reduced wound complications associated with subcuticular suture closure.\textsuperscript{36,38,121,122,123,124} In a 2015 meta-analysis, suture closure was associated with decreased wound separation rates (RR 0.29, 95% CI 0.20–0.43), but a 7-minute increase in operative time (95% CI 3.10–11.31) when compared with staple closure.\textsuperscript{123} There were no significant differences in rates of infection, hematoma or seroma formation, or readmission between the two groups, nor in patient satisfaction or cosmesis.\textsuperscript{123} Outcomes were similar even among obese patients.\textsuperscript{123} A small randomized controlled trial (n = 300) performed in 2020 additionally showed significantly decreased postoperative wound complication and infection rates for suture compared to staples when restricting to emergency cesarean section.\textsuperscript{124}

**Use of antimicrobial-coated suture**

Although not specific to cesarean section, WHO\textsuperscript{71} and NICE\textsuperscript{121} recommend using triclosan-coated suture throughout surgery if available. These types of suture have been shown to reduce the risk of SSI regardless of other suture properties or wound contamination class.

**Postpartum hemorrhage prevention**

WHO\textsuperscript{125} and NICE\textsuperscript{31} recommend routine use of IV oxytocin (or carbetocin if oxytocin is not available) for prevention of postpartum hemorrhage (PPH). Oxytocin bolus plus infusion has been shown to decrease the need for additional uterotonic (OR 0.61, 95% CI 0.48–0.78).\textsuperscript{126} Oxytocin and carbetocin alone have been shown to decrease PPH (blood loss >500 mL: RR 0.58, 95% CI 0.49–0.70; RR 0.72, 95% CI 0.56–0.93, respectively; blood loss >1000 mL: RR 0.59, 95% CI 0.50–0.70; RR 0.87 95% CI 0.62–1.21, respectively).\textsuperscript{127} WHO recommends use of oxytocin 10 IU IM/IV and states if IV bolus is used, they recommend dividing the dose between a bolus and an infusion given improved hemodynamic effects.\textsuperscript{125} WHO additionally acknowledges that carbetocin is considerably more expensive than oxytocin, but in areas where oxytocin is not readily available due to need for refrigeration, heat-stable carbetocin 100 μg IM/IV can be used for prevention of PPH in contexts where its cost is comparable to other uterotonic.\textsuperscript{125} NICE guidelines recommend slow infusion of 5 IU IV oxytocin.\textsuperscript{31} If oxytocin or carbetocin are unavailable, ergometrine for patients without hypertensive disorders or misoprostol may be administered for PPH prevention,\textsuperscript{125} but they are associated with increased risks of side-effects compared with oxytocin.\textsuperscript{125,127} WHO recommends against routine use of injectable prostaglandins (carboprost or sulprostone) for prevention of PPH given a lack of cost-effectiveness data and the substantial side-effect burden.\textsuperscript{125}

**Perioperative fluid and blood pressure management**

WHO\textsuperscript{71} conditionally recommends use of goal-directed fluid management (crystalloid or colloid) intraoperatively given evidence of reductions in SSI,\textsuperscript{128,129} with a goal of achieving euvolemia assessed based on clinical parameters such as blood pressure.\textsuperscript{36,71} Fluid overload and hypovolemia have both been associated with impaired wound healing and increased morbidity and mortality.\textsuperscript{71} For pregnant women, perioperative fluid overload also increases cardiovascular strain, risk of pulmonary edema, and risk of newborn weight loss after delivery.\textsuperscript{36} SOAP recommends limiting intraoperative IV fluid use to <3 L, and switching to a hemorrhage resuscitation blood-transfusion protocol in the event
Hypotension during cesarean section is common, as spinal anesthesia-induced hypotension due to sympathetic blockade occurs in an estimated 70–80% of women if no prophylaxis is used. Traditionally, IV fluid preloading with crystalloid or colloid solution to avoid hypotension has been advised. The 2020 Cochrane review showed low-quality evidence that administration of crystalloid versus no fluid administration at the time of cesarean section avoids postspinal maternal hypotension requiring intervention without any significant improvement in maternal nausea/vomiting. Administration of colloid versus crystalloid did show improvement in maternal hypotension, but not in other maternal or neonatal outcomes, and the authors advise caution in interpretation given the low quality of evidence and potential risk of adverse events associated with colloid administration including renal failure. Vasopressors have been shown to be more effective at reducing spinal anesthesia-induced hypotension and nausea than crystalloid solutions. In light of this, anesthesia practice has shifted from managing maternal spinal-induced hypotension with fluid administration to optimally managing with vasopressor support (preferentially phenylephrine over ephedrine) and anesthesia guidelines recommend administering IV vasopressors prophylactically for prevention of spinal anesthesia-induced hypotension.

**POSTOPERATIVE CARE**

**Postoperative analgesia**

NICE, ERAS, and SOAP guidelines include considering use of postoperative multimodal pain control with scheduled non-steroidal anti-inflammatory drugs (NSAIDs) and/or paracetamol, as this can decrease the need for opioid agents. SOAP guidelines additionally include the use of a neuraxially administered long-acting opioid and consideration of local anesthetic wound infiltration or regional blocks. Pain control can begin intraoperatively with administration of IV ketorolac, if not contraindicated, and IV/rectal paracetamol postoperatively. A 2015 Cochrane review concluded that there was insufficient evidence to recommend the best regimen of post-cesarean section analgesia, but did show significantly decreased need for further analgesics compared to placebo with the use of gabapentin (RR 0.34, 95% CI 0.23–0.51). However, other studies have shown synergistic effects of NSAIDs and paracetamol in reducing postoperative pain. A meta-analysis of five randomized controlled trials with 312 patients showed addition of a postoperative transversus abdominis plane block compared to placebo resulted in decreased morphine consumption, decreased subjective maternal pain scores, and decreased incidence of opioid-related side-effects. In a recent randomized controlled trial in Uganda, a bundle of ERAS measures implemented at time of emergency cesarean section including intrathecal morphine, scheduled NSAIDs and paracetamol, and local wound infiltration with bupivacaine resulted in significantly decreased postoperative pain compared to standard of care. Of the four studies reporting opioid use outcomes in a systematic review of enhanced recovery after cesarean section, two showed reductions in opioid consumption and two showed no differences.

**Removal of urinary catheter and early mobilization**

ERAS recommends immediate postoperative removal of the indwelling urinary catheter if placed during cesarean section for women who do not require strict urinary output monitoring, as this has been shown to lead to earlier mobilization, decreased postoperative bacteriuria, decreased bothersome urinary symptoms, decreased time until first void, and decreased length of stay. Alternatively, NICE and SOAP support removal at 6–12 hours after cesarean section if patients receive intrathecal opioids given the possible association of urinary retention. SOAP does not recommend a specific time interval for catheter removal but rather recommends instituting protocols with specific criteria for catheter removal and management of postoperative urinary retention to encourage mobilization. Early mobilization has been associated with decreased risk of venous thromboembolism and earlier return of bowel function. SOAP recommends ambulation as tolerated, but a minimum target of sitting at edge of bed and getting out of bed to chair by 8 hours postoperatively and ambulating 1–2 times in the hall by 24 hours postoperatively.
Importantly, in low-resource settings, the USAID-supported Fistula Care project recommends prolonged bladder drainage of ≥14 days in patients with prolonged active or obstructed labor to help prevent and treat urogenital fistula.\textsuperscript{139}

### Resumption of regular diet

ERAS\textsuperscript{37} recommends resuming a regular diet within 2 hours postcesarean section and SOAP\textsuperscript{56} endorses advancing to regular diet within 4 hours postcesarean section. Early resumption of regular diet is associated with improved maternal satisfaction,\textsuperscript{140} early ambulation,\textsuperscript{140,141} reduced length of stay,\textsuperscript{140} and earlier return of bowel function without development of ileus symptoms.\textsuperscript{141,142,143}

### Glucose control

ERAS\textsuperscript{37}, CDC\textsuperscript{64} and WHO\textsuperscript{71} recommend optimizing glucose control (SOAP recommends glucose <180–200 mg/dL)\textsuperscript{56} after cesarean section to reduce risk for SSI and prolonged hospital stays. NICE further recommends that insulin not be routinely used to attain tight glycemic control in non-diabetic women.\textsuperscript{121}

### Incisional care

WHO recommends against use of a specific type of dressing for the primary purpose of prevention of SSI.\textsuperscript{71} Furthermore, consideration should be given to removing incisional dressing at 24–48 hours after cesarean section as there is insufficient evidence to support prolonged use.\textsuperscript{31,120} Additionally, the abdomen and incision may be examined daily during hospitalization and prior to hospital discharge.\textsuperscript{31} From the 2016 Cochrane review, the risk of SSI following potentially contaminated surgery (such as cesarean section) is similar irrespective of dressing type: basic wound contact dressings vs. none (RR 1.34, 95% CI 0.82–2.19); hydrocolloid dressings vs. basic wound contact dressings (RR 0.57, 95% CI 0.22–1.51); silver-containing dressings vs. basic wound contact dressings (RR 0.83, 95% CI 0.51–1.37).\textsuperscript{144}

### Negative pressure wound therapy

WHO recommends the use of prophylactic negative pressure wound therapy (NPWT) postoperatively, when available, in obese patients who have undergone cesarean section, as they are at higher risk of postoperative SSI.\textsuperscript{71} Data on NPWT-use are mixed, but a 2016 systematic review and meta-analysis of six randomized controlled trials and one cohort study showed decreased risk of postoperative infections in women with BMI >30 who received prophylactic NPWT after cesarean section compared to a basic sterile surgical dressing (RR 0.45, 95% CI 0.31–0.66).\textsuperscript{145}

### Postoperative antibiotic prophylaxis prolongation

WHO\textsuperscript{71} and CDC\textsuperscript{64} recommend against routine use of prolonged postoperative antibiotics as they do not result in improved outcomes compared with appropriately timed single-dose preoperative antibiotic prophylaxis, have been found to be more costly, and may contribute to the development of antibiotic resistance.\textsuperscript{71,146,147,148} In low-resource settings, particularly in sub-Saharan Africa, there is routine use of multiday postoperative antibiotics for the purposes of SSI prophylaxis due to poor compliance with evidence-based preoperative antibiotic use and concern for elevated risk of SSI related to poor hygienic practices.\textsuperscript{149,150} However, even in these settings, studies support using preoperative antibiotic prophylaxis instead of postoperative prophylaxis. For example, randomized controlled trials in Tanzania\textsuperscript{147} and Zimbabwe\textsuperscript{146} showed no significant differences in infection rates for appropriately timed preoperative antibiotic administration compared to multiday postoperative antibiotic regimens, suggesting the opportunity for significant cost savings and improved resource utilization by switching to an appropriate preoperative regimen.\textsuperscript{146} In Kenya, postcesarean section infection rates were found to be significantly lower at a hospital that routinely administered appropriately timed preoperative antibiotics (4%) versus a hospital that only routinely administered postoperative antibiotics (9.3%) (OR 0.41, 95% CI 0.20–0.82).\textsuperscript{148}

### Thromboprophylaxis

ACOG recommends routine use of pneumatic compression devices until full ambulation to reduce the risk of venous
thromboembolism (VTE) for all women undergoing cesarean section. Pharmaceutical prophylaxis may be considered for high-risk women, such as those with a history of thromboembolism or with a high-risk thrombophilia. The Society of Maternal Fetal Medicine published guidelines in 2020 which delineated who should receive pharmaceutical thromboprophylaxis in addition to mechanical thromboprophylaxis (Table 3). RCOG recommends that anyone who undergoes cesarean section while in labor receive low-molecular weight heparin for 10 days postoperatively regardless of other risk factors, as well as anyone undergoing elective cesarean section with another risk factor for VTE (age >35 years, obesity, parity >3, family history of VTE, low-risk thrombophilia, gross varicose veins, systemic infection, immobility, pre-eclampsia, multifetal gestation, preterm delivery, and postpartum hemorrhage). The 2014 Cochrane review looking at postcesarean section thromboprophylaxis showed no differences in thromboembolic events, symptomatic pulmonary embolism, and symptomatic deep vein thrombosis in women who received heparin versus no heparin, low-molecular weight heparin versus unfractionated heparin, or low-molecular weight heparin for 5 days versus 10 days. Additionally, one trial identified in the Cochrane review showed that women who received heparin had increased risk of bleeding complications (RR 5.03, 95% CI 2.49–10.18, 580 women) compared to women who did not receive heparin.

Postpartum follow-up
ERAS and NICE recommend providing patients with written discharge instructions with postoperative precautions. ACOG recommends at least two assessments in the postpartum period, including an assessment within 3 weeks postpartum, either in-person or by phone, to address any early complications or concerns and a more comprehensive in-person postpartum visit within 12 weeks postpartum. Telephone assessments have been shown to help diagnose wound complications even within low-resource settings.

Table 3 Cesarean section (CS) evidence-based practices and recommendations.

<table>
<thead>
<tr>
<th>Component</th>
<th>Recommendation and guidelines</th>
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<tbody>
<tr>
<td><strong>Preoperative considerations</strong></td>
<td></td>
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<tr>
<td>Gestational age timing of planned CS</td>
<td>Recommend planned CS be performed no earlier than 39 weeks' gestational age unless otherwise medically indicated</td>
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<tr>
<td>NICE: Risk of respiratory morbidity is increased in babies born by CS before labor, but this risk decreases significantly after 39 weeks. Therefore planned CS should not routinely be carried out before 39 weeks.</td>
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<tr>
<td>ACOG: Nonmedically indicated delivery, including CS, inductions of labor, and cervical ripening should not occur before 39 0/7 weeks of gestation.</td>
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<tr>
<td>CS skills and team training</td>
<td>Consider incorporating CS knowledge and skills-training curriculum including evidence-based intraoperative techniques; team-based training and simulation on emergencies during CS for surgical team including physician, nurse, nursing assistants, and anesthesia team; and team-based training and simulation on implementing the CS bundle</td>
</tr>
<tr>
<td>Surgical huddle Surgical safety checklist</td>
<td>Recommend performing a surgical team huddle with use of a surgical safety checklist prior to start of CS</td>
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<tr>
<td>WHO: Use the WHO Patient Safety surgical safety checklist or similar safety check to ensure that steps to promote safe surgery are accomplished in a systematic and timely fashion.</td>
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<tr>
<td>Preoperative fasting carbohydrate load</td>
<td>Recommend avoiding prolonged fasting prior to CS</td>
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<tr>
<td>ERAS: Women should be encouraged to drink clear fluids (pulp-free juice, coffee, or tea without milk) until 2 hours before surgery. A light meal may be eaten up to 6 hours before surgery (quality of evidence: high, strength of recommendation: strong); oral carbohydrate fluid supplementation, 2 hours before cesarean section, may be offered to non-diabetic women.</td>
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<tr>
<td>Component</td>
<td>Recommendation and guidelines</td>
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| **Preoperative bathing** | **Recommend patients bathe or shower prior to surgery**<br>WHO: It is good clinical practice for patients to bathe or shower prior to surgery. The panel suggests that either a plain or antimicrobial soap may be used for this purpose (Quality of evidence: moderate, strength of recommendation: conditional).<sup>71</sup><br>NICE: Advise patients to shower or have a bath (or help patients to shower, bath or bed bath) using soap, either the day before, or on the day of, surgery.<sup>72</sup><br>CDC: Advise patients to shower or bathe (full body) with soap (antimicrobial or

| Anesthetic choice | **Recommend using neuraxial anesthesia if no maternal contraindication for planned CS**<br>NICE: Women who are having a CS should be offered regional anesthesia because it is safer and results in less maternal and neonatal morbidity than general anesthesia. This includes women who have a diagnosis of placenta previa.<sup>31</sup><br>ERAS: Regional anesthesia is the preferred method of anesthesia for cesarean section (quality of evidence: low, strength of recommendation: strong).<sup>36</sup> |

| Pre-anesthetic medications | **Recommend administering H2 receptor blockers and antacids**<br>NICE: To reduce the risk of aspiration pneumonitis women should be offered antacids and drugs (such as H2 receptor antagonists or proton pump inhibitors) to reduce gastric volumes and acidity before cesarean section; Women having a CS should be offered antiemetics (either pharmacological or acupressure) to reduce nausea and vomiting during CS.<sup>31</sup><br>ERAS: Antacids and H2 receptor antagonists should be administered as premedication to reduce risk from aspiration pneumonitis (quality of evidence: low, strength of recommendation: strong); anti-emetic medications are effective for prevention of nausea and vomiting during CS. Multimodal approach should be applied to treat nausea and vomiting (quality of evidence: moderate, strength of recommendation: strong).<sup>36</sup> |

| Preoperative antibiotics | **Recommend administering preoperative antibiotics within 30–60 minutes of CS and before skin incision**<br>**Unlabored:** cefazolin or clindamycin + gentamicin if penicillin allergy.<br>**Labored:** cefazolin + azithromycin<br>WHO: Recommends administration of surgical antibiotic prophylaxis prior to surgical incision (quality of evidence: low, strength of recommendation: strong); recommends administration of surgical antibiotic prophylaxis within 120 minutes before incision, while considering the half-life of the antibiotic (for example, administration closer to the incision time or >60 minutes for antibiotics section with a short half-life such as cefazolin) (quality of evidence: moderate, strength of recommendation: strong).<sup>71</sup><br>NICE: Offer women prophylactic antibiotics section at CS before skin incision. Choose antibiotics effective against endometritis, urinary tract and wound infections.<sup>31</sup><br>ERAS: IV antibiotics section should be administered routinely within 60 min before the Cs skin incision. A first-generation cephalosporin is recommended; in women in labor or with ruptured membranes, addition of azithromycin confers further reduction in postoperative infections (quality of evidence: high, strength of recommendation: strong).<sup>36</sup><br>ACOG: Normal BMI or weight <80Kg – 1 g cefazolin or clindamycin 900 mg plus aminoglycoside 5 mg/kg. Obese BMI >30 or weight >80 kg – cefazolin 2–3 g, or clindamycin 900 mg plus aminoglycoside 5 mg/kg. Administer within 60 minutes before the start of the cesarean section. Addition of azithromycin, infused over 1 hour, to a standard antibiotic prophylaxis regimen may be considered for women undergoing non-elective CS.<sup>70</sup> |
### Hair removal

**Recommend avoiding hair-removal unless necessary**

WHO: Recommends that hair should either not be removed, or if necessary, should be removed only with a clipper. Shaving is strongly discouraged at all times, whether preoperatively or in the operating room (quality of evidence: moderate, strength of recommendation: strong).\(^{71}\)

NICE: Do not use hair removal routinely to reduce the risk of SSI; If hair has to be removed, use electric clippers with a single-use head on the day of surgery. Do not use razors for hair removal, because they increase the risk of SSI.\(^{71}\)

### Abdominal skin preparation

**Recommend prepping the abdomen with alcohol-based chlorhexidine gluconate (CHG) solution prior to incision, and allow to dry for 3 minutes prior to draping**

WHO: Recommends alcohol-based antiseptic solution based on chlorhexidine gluconate for surgical skin preparation prior to surgical procedures (quality of evidence: low to moderate, strength of recommendation: strong).\(^{71}\)

NICE: Prepare the skin at the surgical site immediately before incision using an antiseptic preparation. First choice unless contraindicated or the surgical site is next to a mucous membrane: alcohol-based solution of CHG.\(^{71}\)

ERAS: Chlorhexidine-alcohol is preferred to aqueous povidone-iodine solution for reduction of postCS infections (quality of evidence: low, strength of recommendation: strong).\(^{36}\)

ACOG: Preoperative skin cleansing before CS with an alcohol-based solution should be performed unless contraindicated. A reasonable choice is a chlorhexidine-alcohol skin preparation.\(^{70}\)

CDC: Perform intraoperative skin preparation with an alcohol-based antiseptic agent unless contraindicated (quality of evidence: high, strength of recommendation: strong).\(^{64}\)

### Vaginal preparation

**Recommend vaginal preparation with 10% povidone-iodine or CHG solution with low alcohol content prior to all unscheduled CS**

Consider vaginal preparation for planned CS

ERAS: Vaginal preparation with povidone-iodine solution should be considered for the reduction of postCS infections (quality of evidence: moderate, strength of recommendation: weak).\(^{36}\)

ACOG: Vaginal cleansing before CS in laboring patients and those with ruptured membranes using either povidone-iodine or CHG can be considered. Solutions of CHG with low contractions of alcohol (e.g. 4%) are safe and effective for off-label use as vaginal surgical preparations.\(^{70}\)

### Indwelling urinary catheter placement

**Recommend bladder drainage prior to CS**

Consider placement of indwelling urinary catheter, especially in setting of prolonged or obstructed labor

NICE: Women having CS with regional anesthesia require an indwelling urinary catheter to prevent over-distention of the bladder because the anesthetic block interferes with normal bladder function. Removal of the urinary bladder catheter should be carried out once a woman is mobile after a regional anesthetic and not sooner than 12 hours after the last epidural dose.\(^{31}\)

ERAS: Urinary catheter should be removed immediately after cesarean section, if placed during surgery (quality of evidence: low, strength of recommendation: strong).\(^{37}\)
### Component: Body Temperature

<table>
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<th>Recommendation and guidelines</th>
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<tr>
<td><strong>WHO:</strong> Suggests use of warming devices in the operating room and during the surgical procedure for patient body warming to help reduce SSI (quality of recommendation: moderate, strength of recommendation: conditional) [71].</td>
</tr>
<tr>
<td><strong>ERAS:</strong> Appropriate patient temperature monitoring is needed to apply warming devices and avoid hypothermia (quality of evidence: low, strength of recommendation: strong); forced air warming, IV fluid warming, and increasing operative room temperature are recommended to prevent hypothermia (quality of evidence: moderate, strength of recommendation: strong) [36].</td>
</tr>
<tr>
<td><strong>CDC:</strong> Maintain perioperative normothermia (quality of evidence: high to moderate, strength of recommendation: strong) [64].</td>
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### Intraoperative Techniques and Considerations

#### Skin Incision

**Recommend routine use of a low-transverse abdominal skin incision, either Joel-Cohen or Pfannenstiel**

**NICE:** CS should be performed using a transverse abdominal incision because this is associated with less postoperative pain and an improved cosmetic effect compared with a midline incision; The transverse incision of choice should be the Joel-Cohen incision, because it is associated with shorter operating times and reduced febrile morbidity [21].

#### Bladder Flap

**There is insufficient evidence to recommend routine creation of a bladder flap prior to making the uterine incision**

#### Hysterotomy Site and Type

**Recommend transverse incision in the lower uterine segment if able to be performed**

**For CS performed for failure to progress, recommend transverse incision higher in the lower uterine segment**

#### Hysterotomy Extension

**Recommend that the hysterotomy is extended bluntly in the cephalad-caudal direction**

**NICE:** When there is a well formed lower uterine segment, blunt rather than sharp extension of the uterine incision should be used because it reduces blood loss, incidence of postpartum hemorrhage and the need for transfusion at CS [31].

**ERAS:** Blunt expansion of a transverse uterine hysterotomy is recommended to reduce surgical blood loss (quality of evidence: moderate, strength of recommendation: weak) [36].

#### Placental Delivery

** Recommend delivery of the placenta using gentle cord traction**

**WHO:** Cord traction is the recommended method for removal of the placenta in CS (quality of evidence: moderate, strength of recommendation: strong) [102].

**NICE:** The placenta should be removed using controlled cord traction and not manual removal as this reduces the risk of endometritis [31].

#### Hysterotomy Closure

**Recommend double-layered closure of the hysterotomy**

**NICE:** The effectiveness and safety of single layer closure of the uterine incision is uncertain. Except within a research context, the uterine incision should be sutured with two layers.

**ERAS:** closure of the hysterotomy incision in two layers may be associated with decreased risk of uterine rupture (quality of evidence: low, strength of recommendation: weak)

#### Uterine Exteriorization

**There is insufficient evidence to recommend for or against routine uterine exteriorization**

**NICE:** Intrapерitoneal repair of the uterus at cesarean section should be undertaken. Exteriorization of the uterus is not recommended because it is associated with more pain and does not improve operative outcomes such as hemorrhage and infection [31].

**SOAP:** Limit/avoid uterine exteriorization and abdominal saline irrigation by surgeon [56].
**Intraperitoneal irrigation**

- **Recommend against routine intraperitoneal irrigation**
- NICE: Do not use intracavitary lavage to reduce the risk of SSI.
- SOAP: Limit/avoid uterine exteriorization and abdominal saline irrigation by surgeon.

**Peritoneum closure**

- **Recommend against routine closure of the parietal peritoneum**
- NICE: Neither the visceral nor the parietal peritoneum should be sutured at CS because this reduces operating time and the need for postoperative analgesia, and improves maternal satisfaction.
- ERAS: The peritoneum does not need to be closed as it is not associated with improved outcomes, but increases operative time (quality of evidence: low, strength of recommendation: weak).

**Subcutaneous tissue closure**

- **Recommend closure of the subcutaneous tissue if it is ≥2 cm in depth**
- NICE: Routine closure of the subcutaneous tissue space should not be used, unless the woman has >2 cm subcutaneous fat.
- ERAS: in women with >2 cm of subcutaneous tissue, reapproximation of the tissue layer should be performed (quality of evidence: moderate, strength of recommendation: weak).

**Use of superficial wound drains**

- **Recommend against routine placement of subcutaneous drains**
- NICE: Superficial wound drains should not be used at CS because they do not decrease the incidence of wound infection or wound hematoma.

**Skin closure**

- **Recommend skin closure with subcuticular suture**
- NICE: Consider using sutures rather than staples to close the skin after CS to reduce the risk of superficial wound dehiscence.
- ERAS: Skin closure should be performed using subcuticular suture in most cases, because of evidence of reduced wound separation if staples were removed <4 days after surgery (quality of evidence: moderate, strength of recommendation: weak).

**Use of antimicrobial-coated sutures**

- **Consider use of triclosan-coated suture if available to reduce the risk of SSI**
- WHO: Suggests the use of triclosan-coated sutures for the purpose of reducing the risk of SSI, independent of the type of surgery (quality of evidence: moderate, strength of recommendation: conditional).
- NICE: When using sutures, consider using antimicrobial triclosan-coated sutures to reduce the risk of SSI.

**Postpartum hemorrhage (PPH) prevention**

- **Recommend routine administration of IV oxytocin or carbetocin as first-line for prevention of PPH**
- WHO: Oxytocin 10 IU (IV or IM) is the preferred uterotonic drug for prevention of PPH in CS (quality of evidence: moderate, strength of recommendation: strong).
- NICE: Oxytocin 5 IU by slow IV injection should be used at CS to encourage contraction of the uterus and to decrease blood loss.

**Perioperative fluid and blood pressure management**

- **Recommend maintaining euvo lemia through judicious use of IV fluid administration**
- **Recommend preferential use of vasopressors for management of spinal-induced hypotension at time of CS**
- WHO: Suggests the use of goal-directed fluid therapy intraoperatively to reduce the risk of SSI (quality of evidence: low, strength of recommendation: conditional).
- NICE: Women who are having a CS under regional anesthesia should be offered IV ephedrine or phenylephrine, and volume pre-loading with crystalloid or colloid to reduce the risk of hypotension during CS.
- ERAS: Perioperative and intraoperative euvo lemia appear to lead to improved maternal and...
<table>
<thead>
<tr>
<th>Component</th>
<th>Recommendation and guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neonatal outcomes after CS (quality of evidence: low to moderate, strength of recommendation: strong)</td>
<td>SOAP: Limit IV fluids to &lt;3 L for routine cases (suggested). Prevent and treat spinal anesthesia induced hypotension; optimally managed with prophylactic vasopressor infusion: for example phenylephrine (or norepinephrine) infusion.</td>
</tr>
<tr>
<td>Postoperative considerations</td>
<td></td>
</tr>
<tr>
<td>Postoperative analgesia</td>
<td><strong>Recommend postoperative multimodal pain control with scheduled non-steroidal anti-inflammatory drugs as this can decrease need for opioid agent use</strong></td>
</tr>
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<td></td>
<td>NICE: If no contraindication, NSAIDs should be offered postCS as an adjunct to other analgesics, because they reduce the need for opioids.</td>
</tr>
<tr>
<td></td>
<td>ERAS: Multimodal analgesia that include regular NSAIDs and paracetamol is recommended for enhanced recovery after cesarean section (quality of evidence: moderate, strength of recommendation: strong).</td>
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<tr>
<td></td>
<td>SOAP: Multimodal analgesia protocols include low-dose long-acting neuraxial opioid such as morphine, scheduled NSAIDs, scheduled acetaminophen, local anesthetic techniques as indicated.</td>
</tr>
<tr>
<td>Removal of indwelling urinary catheter</td>
<td><strong>Recommend removal of indwelling urinary catheter as soon as feasible if placed at the time of CS and encouraging early mobilization</strong></td>
</tr>
<tr>
<td>Early mobilization</td>
<td>Consider maintaining urinary catheter for ≥14 days in patients with prolonged active or obstructed labor to help prevent and treat urogenital fistula</td>
</tr>
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<td></td>
<td>NICE: Women having CS with regional anesthesia require an indwelling urinary catheter to prevent over-distention of the bladder because the anesthetic block interferes with normal bladder function. Removal of the urinary bladder catheter should be carried out once a woman is mobile after a regional anesthetic and not sooner than 12 hours after the last epidural dose.</td>
</tr>
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<td></td>
<td>ERAS: Urinary catheter should be removed immediately after CS, if placed during surgery (quality of evidence: low, strength of recommendation: strong); early mobilization after CS is recommended (quality of evidence: very low, strength of recommendation: weak).</td>
</tr>
<tr>
<td></td>
<td>SOAP: Urinary catheter should be removed 6–12 hours postpartum. Construct protocols to establish criteria for appropriate removal, and to manage post-catheter removal urinary retention. Ambulation should occur soon after return of motor function.</td>
</tr>
<tr>
<td>Resumption of regular diet</td>
<td><strong>Recommend early resumption of regular diet postCS</strong></td>
</tr>
<tr>
<td></td>
<td>NICE: Women who are recovering well after CS who do not have complications can eat and drink when they feel hungry or thirsty.</td>
</tr>
<tr>
<td></td>
<td>ERAS: A regular diet within 2 hours postCS is recommended (quality of evidence: high, strength of recommendation: strong).</td>
</tr>
<tr>
<td></td>
<td>SOAP: Ice chips and/or water within 60 minutes of admission to the post-anesthesia care unit; heparin/saline lock the IV once oxytocin infusion complete, tolerating fluids, and urine output adequate; advance to regular diet ideally within 4 hours postCS, as tolerated.</td>
</tr>
<tr>
<td>Glucose control</td>
<td><strong>Recommend tight postoperative glycemic control for diabetic women</strong></td>
</tr>
<tr>
<td></td>
<td>NICE: Do not give insulin routinely to patients who do not have diabetes to optimize blood glucose postoperatively as a means of reducing SSI.</td>
</tr>
<tr>
<td></td>
<td>ERAS: Tight control of capillary blood glucose postoperatively is recommended (quality of evidence: low, strength of recommendation: strong).</td>
</tr>
<tr>
<td></td>
<td>SOAP: Patients with diabetes should ideally be scheduled as the first case of the day; maintain normoglycemia (&lt;180–200 mg/dL); check maternal/neonatal glucose as per hospital protocol.</td>
</tr>
<tr>
<td>Component</td>
<td>Recommendation and guidelines</td>
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| Incisional care | **Recommend removing incisional dressing at 24–48 hours after CS**
Recommend inspect incision and examine abdomen daily during hospitalization and prior to hospital discharge

WHO: Suggests not using any type of advanced dressing (including hydrocolloid, hydroactive, silver-containing, and polyhexamethylene biguanide) on primarily closed surgical wounds for the purpose of preventing SSI (quality of evidence: low, strength of recommendation: conditional).[^71]

NICE: Remove the dressing 24 hours after the CS.[^31] Use sterile saline for wound cleansing up to 48 hours after surgery. Advise patients that they may shower safely 48 hours after surgery.[^31]

| Prophylactic negative pressure wound therapy | Consider use of negative pressure wound therapy postoperatively in obese patients who have undergone CS
WHO: Suggests the use of prophylactic negative pressure wound therapy in adult patients on primarily closed surgical incisions in high-risk wound, while taking resources into account (quality of evidence: low, strength of recommendation: conditional).[^71]

| Postoperative antibiotic prophylaxis prolongation | **Recommend against routine use of postoperative antibiotics for the purpose of SSI prophylaxis**
WHO: Recommends against the prolongation of surgical antibiotic prophylaxis after completion of the operation for the purpose of preventing SSI (quality of evidence: moderate, strength of recommendation: strong).[^71]

CDC: In clean and clean-contaminated procedures, do not administer additional prophylactic antimicrobial agent doses after the surgical incision is closed in the operating room, even in the presence of a drain. (quality of evidence: high, strength of recommendation: strong).[^64]

| Thromboprophylaxis | **Recommend routine use of pneumatic compression devices to reduce the risk of venous thromboembolism for all women undergoing CS, which should remain in place until the patient is fully ambulatory**

Consider addition of pharmaceutical prophylaxis for high-risk women, such as those with a history of thromboembolism or with a high-risk thrombophilia, based on local guidelines

NICE: Offer thromboprophylaxis to women having a CS because they are at increased risk of venous thromboembolism. The choice of method of prophylaxis (for example, graduated stockings, hydration, early mobilization, low molecular weight heparin) should account for risk of thromboembolic disease.[^31]

ERAS: Pneumatic compression stockings should be used to prevent thromboembolic disease in patients who undergo CS (quality of evidence: low, strength of recommendation: strong); heparin should not be used routinely for venous thromboembolism prophylaxis in patients after cesarean section (quality of evidence: low, strength of recommendation: weak).[^77]

SMFM: recommend that all women who undergo CS receive sequential compression devices starting preoperatively until fully ambulatory (Grade 1C: strong recommendation, low-quality evidence); all women with personal history of DVT or PE who undergo CS receive both mechanical thromboprophylaxis and pharmaceutical prophylaxis until 6 weeks postpartum (Grade 2C: weak recommendation, low-quality evidence); those with any inherited thrombophilia (high- or low-risk) but no personal history of DVT/PE receive mechanical prophylaxis and pharmaceutical prophylaxis for 6 weeks postpartum (Grade 1C: strong recommendation, low-quality evidence), recommend use of low molecular weight heparin as preferred pharmaceutical agent in pregnancy and postpartum (quality of evidence: low, strength of recommendation: strong), and suggest use of intermediate-dose enoxaparin for women with Class III obesity or higher if they require thromboprophylaxis (quality of evidence: low, strength of recommendation: weak).[^51]

| Patient discharge | **Recommend close postoperative patient follow-up for evidence of wound complication**


MANAGEMENT OF COMPLICATIONS

Postpartum hemorrhage treatment

For treatment of postpartum hemorrhage (PPH) during cesarean section, WHO recommends administration of IV oxytocin, even for women who have already received oxytocin for PPH prophylaxis. If oxytocin is unavailable or fails to control PPH, administration of IV ergometrine, oxytocin-ergometrine, or a prostaglandin (sublingual misoprostol 800 μg) is recommended (quality evidence: low, strength of recommendation: strong). Ergometrine with oxytocin and misoprostol with oxytocin have also been shown to decrease PPH compared with oxytocin alone (blood loss >500 mL: RR 0.69, 95% CI 0.57–0.83; RR 0.73 95% CI 0.60–0.90, respectively; blood loss >1000 mL: RR 0.77, 95% CI 0.61–0.95; RR 0.90, 95% CI 0.72–1.14, respectively). However, ergometrine and misoprostol are associated with increased risks of side-effects compared to oxytocin alone, and ergometrine should be avoided in women with hypertensive disorders. WHO recommends that IV tranexamic acid 1000 mg in 10 mL be administered as standard of care in all clinically diagnosed cases of PPH regardless of etiology (quality evidence: moderate, strength of recommendation: strong). This dose should be administered IV only, run over 10 minutes, and can be repeated once if bleeding is ongoing 30 minutes after initial dose or recurs after 24 hours. Tranexamic acid has been shown to significantly reduce death from bleeding when administered within 3 hours of the inciting event (RR 0.69, 95% CI 0.52–0.91). IV fluid resuscitation should also be performed preferentially with crystalloid solution instead of colloids (quality of evidence: low, strength of recommendation: strong).

See “Surgical Management of Intractable Pelvic Hemorrhage” for further details on managing PPH including placing compression sutures such as a B-Lynch stitch or performing internal iliac artery ligation. Uterine balloon tamponade can also be considered during cesarean section. For delayed hemorrhage in higher resource settings, uterine artery embolization through interventional radiology may be an option. Cesarean section hysterectomy remains the mainstay of definitive management in cases of intractable intraoperative hemorrhage when all other temporizing measures have failed.

Bladder injury

Bladder injury or ureteric injury at time of cesarean section is a rare but important occurrence. Estimates of bladder injury at time of cesarean section range from 0.08 to 0.94%. History of prior cesarean section increases risk of bladder injury (adjusted OR 3.82, 95% CI 1.62–8.97). Emergent delivery, labor before cesarean section, failed trial of labor after cesarean section (TOLAC), uterine rupture, adhesions, and BMI were also significantly associated with increased risk of bladder injury. While the incidence of cystotomy is higher in women undergoing repeat as compared to primary cesarean section, it appears to be similar overall for women undergoing elective repeat
cesarean section versus women who attempt TOLAC (includes women who have a successful vaginal birth after cesarean section and those who convert to unplanned cesarean section).\textsuperscript{163} However, women who undergo unplanned cesarean section after failed TOLAC did have the highest incidence of bladder injury.\textsuperscript{163}

Most bladder injuries at time of cesarean section (95%) occur at the dome of the bladder.\textsuperscript{161} They may occur at time of bladder flap creation (43%), entry into the peritoneal cavity (33%), or at uterine incision/delivery of the fetus (24%).\textsuperscript{161} Prompt recognition and repair is ideal or complications can ensue including the development of uroperitonitis or urogenital fistula. Diagnosis may be made by seeing extravasation of urine or exposure of the catheter balloon in the operative field, laceration of the detrusor muscle, or new onset gross hematuria in the urinary catheter bag.\textsuperscript{160} Strategies to diagnose an injury if uncertain include bladder instillation with sterile milk, indigo carmine, or methylene blue through an indwelling urinary catheter. A simple cystotomy in the bladder dome may be repaired in two layers. The first layer is traditionally performing using a running 3–0 or 4–0 absorbable suture. Confirmation of watertight closure should be performed after closure of this first layer with bladder instillation of any of the aforementioned agents. A second imbricating layer is then performed.\textsuperscript{160} An indwelling urinary catheter should remain in place and the bladder continuously drained for 7–14 days. For injuries to the trigone (close to the ureter(s)) or the ureter(s), specialist opinion should be sought if available as ureteral reimplantation may be necessary.

Abnormally adherent placenta

Morbidly adherent placenta, or placenta accreta spectrum (PAS), is increasing in incidence with increased cesarean section rates. In 2016, a nationally representative study found 1 in 272 women in the United States with a birth-related hospital discharge diagnosis had a diagnosis of placenta accreta.\textsuperscript{164} Three categories of PAS are described: (1) adherent placenta accreta where villi adhere to the myometrium, (2) placenta increta, where villi invade the myometrium, and (3) placenta percreta, where villi invade through the full thickness of the myometrium and the uterine serosa, sometimes invading adjacent pelvic structures such as bladder, bowel, or vessels.\textsuperscript{165} Risk for PAS increases with placenta previa, increasing number of prior cesarean section (risk with placenta previa of 3%, 11%, 40%, 61%, and 67% for first, second, third, fourth, fifth cesarean section, respectively),\textsuperscript{5} history of prior placenta accreta, prior uterine surgeries or curettage, advanced maternal age, and multiparity.\textsuperscript{164,166}

ACOG\textsuperscript{164} and RCOG\textsuperscript{166} both have guidelines for the management of PAS, largely within the context of high resource settings. In 2017, the International Federation of Gynaecology and Obstetrics (FIGO) created consensus guidelines for conservative and nonconservative management of PAS taking into account high and low resource settings.\textsuperscript{167,168} For planned cesarean section with known preoperative concern for PAS, guidelines recommend delivery in a tertiary-care facility with a multidisciplinary team (including access to vascular and trauma surgeons if needed) and access to a blood bank, given the risk for life-threatening hemorrhage.\textsuperscript{164,166,168} Access to cell salvage technology in this setting is ideal. Cesarean section hysterectomy is recommended for definitive surgical management of PAS; conservative management with uterine preservation should be reserved only for well-counseled women who highly desire fertility preservation and are able follow up with specialized centers.\textsuperscript{167,168} FIGO recommends that in high- and low-resource settings, an expert in complex pelvic surgery should be available throughout the surgical procedure (quality of evidence: moderate, strength of recommendation: strong), and scheduled, nonemergent, delivery is advisable (quality of evidence: low, strength of recommendation: strong).\textsuperscript{168} Exact timing of nonemergent delivery may depend on local circumstances and clinical presentation, but can be considered starting at 34 weeks if the patient is stable after administration of antenatal corticosteroids for fetal lung maturity.\textsuperscript{168}

If cesarean section hysterectomy is planned, a vertical midline skin incision is most often recommended to ensure appropriate access and ability to perform hysterotomy above the level of the placental implantation, especially if the placental margin is above the level of the lower uterine segment (quality of evidence: low, strength of recommendation: weak).\textsuperscript{168} If available, preoperative or intraoperative ultrasound can help localize the placental verge and assist in planning the uterine incision. If suspicion for PAS is high and cesarean section hysterectomy is planned, FIGO recommends not using uterotonics or attempting placental removal if it does not spontaneously deliver as this has been shown to worsen intraoperative hemorrhage (quality of evidence: moderate, strength of recommendation: strong).\textsuperscript{168}
Ideally, total hysterectomy is performed, especially in the case of placenta increta or percreta where subtotal hysterectomy without complete removal of the cervix may not remove all the invasive tissue (quality of evidence: low, strength of recommendation strong). Blood loss can be minimized through administration of tranexamic acid 1 g slow IV or 1000–1300 mg orally immediately prior to or during cesarean section in both high- and low-resource settings if available (quality of evidence: high, strength of recommendation: strong). In the setting of massive maternal hemorrhage, ACOG recommends initiating massive transfusion in the range of 1 : 1 : 1 to 1 : 2 : 4 of packed red blood cells: fresh frozen plasma: platelets (quality of evidence: high, strength of recommendation: strong). In individualized cases of significant placental percreta where patient morbidity would be reduced with some placental resorption, the placenta may be left in-situ and delayed hysterectomy performed (between 3 and 12 weeks postpartum), but this practice places patients at risk for hemorrhage, sepsis, and coagulopathy during the interim time (recommend considering in high resource settings only, quality of evidence: low, strength of recommendation: weak). If PAS is encountered after delivery of the neonate, the case should be paused until the appropriate surgical specialists arrive; if no specialist is available to perform hysterectomy, transfer of the patient is indicated after closure of the hysterotomy and may additionally require temporizing measures including abdominal packing, blood transfusion, and tranexamic acid administration as available.

Planned conservative management of PAS, or attempt at uterine preservation, may be an option for appropriately counseled women who desire to preserve their fertility and are highly reliable; this planned approach requires compliance with extensive long-term monitoring and should only be undertaken in high-resource settings/centers with appropriate expertise (quality of evidence: moderate, strength of recommendation: strong). If the upper margin of the placenta does not extend into the upper margin of the uterus, a low transverse incision may be considered when no cesarean section hysterectomy is planned; otherwise, the initial skin and uterine incisions are similar to those for cesarean section hysterectomy. After the neonate is delivered, the placenta should be left in situ. If PAS diagnosis is uncertain but suspected, failure of the placenta to separate with gentle controlled cord traction may confirm PAS. The cord is then clamped and cut close to the placental insertion and the hysterotomy incision is closed in the usual manner. Postoperative prophylactic antibiotic administration with amoxicillin and clavulanic acid or clindamycin for penicillin allergic patients is advised if the placenta remains in situ, but there is insufficient evidence to guide duration of antibiotic course (quality of evidence: low strength of recommendation: weak). The use of postoperative methotrexate or routine use of surgical or radiological uterine devascularisation is not recommended. In a small French study of 167 women with PAS disorders, the placenta was left partially or totally in situ for 59.3% of cases with successful uterine preservation in 78% of cases and severe maternal morbidity in only 6% of cases. Complications may be higher in cases of placenta percreta that are managed conservatively; severe maternal morbidity occurred in 16.7% of the placenta percreta cases where the placenta was left in-situ in the French study. ACOG recommends reserving uterine preservation for carefully selected cases after detailed counseling about the risks, uncertain benefits, and efficacy of expectant management and states it should be considered investigational (quality of evidence: low, strength of recommendation: weak).

Hypertensive emergencies

According to global estimates from 2002 to 2010, approximately 4.6% (95% CI 2.7–8.2) of deliveries are impacted by hypertensive disorders of pregnancy, although this estimate varies greatly by region ranging from 1.0% in the WHO Eastern Mediterranean Region to 5.6% in the African Region. Hypertensive disorders are the second leading cause of maternal death globally, accounting for approximately 18% of maternal deaths. Treatment of severe hypertension (sustained systolic blood pressure ≥160 mmHg and/or diastolic blood pressure ≥110 mmHg for 15 minutes) is universally recommended to reduce the risk of end-organ damage, including occurrence of cerebrovascular accident, and to reduce the risk of maternal mortality. First-line treatment options include oral nifedipine, labetalol, and hydralazine. A 2013 Cochrane review suggests that there is insufficient evidence to preferentially recommend any one of the aforementioned agents for peripartum management of severe hypertension. However, a meta-analysis has shown that nifedipine may have superior maternal outcomes as compared to labetalol (e.g., reduced risk of persistent hypertension (RR 0.42, 95% CI 0.18–0.96) and reported maternal side-effects (RR 0.57, 95% CI 0.35–
and may be advantageous in lower resource settings due to nifedipine’s improved availability, reduced cost, and ease of use.\textsuperscript{178} A 2019 randomized controlled trial additionally showed that administration of oral nifedipine was 1.8 times more likely to achieve target blood pressure compared to IV labetalol and resulted in faster time to achieve target blood pressure (MD 9.5 minutes, \( p = 0.002 \)) during treatment of acute severe hypertension.\textsuperscript{182} Although there are no specific recommendations for hypertensive management during cesarean section, hemodynamic optimization preoperatively using the same first-line agents is recommended to improve intraoperative outcomes.\textsuperscript{179,180,181}

**CONCLUSION**

Cesarean section is a lifesaving and cost-effective intervention when performed safely using evidence-based practices, but in certain settings may result in substantial maternal and neonatal morbidity and mortality. Cesarean section can also confer significant maternal and neonatal risks in subsequent pregnancies. Although cesarean section delivery is increasing worldwide and is likely overutilized in some settings, it is still underutilized in many lower-resource settings. Additionally, associate clinicians often perform these cesarean section and may not be adequately trained. In order to improve outcomes and ensure access to safe, appropriately indicated cesarean section, we have outlined a set of evidence-based practice recommendations for the training and performance of cesarean section, and the care of cesarean section patients. These recommendations can be incorporated into training and implemented as facility-wide cesarean section bundles to reduce complications such as SSI, as well as enhance recovery after surgery and reduce length of hospital stay.

**PRACTICE RECOMMENDATIONS**

- Train all providers who will be performing cesarean section on cesarean section surgical techniques, appropriate indications for cesarean section, and evidence-based practices.
- Consider task-shifting through education of associate clinicians to perform safe cesarean section in regions where it is underutilized (cesarean section rate <10%), as this may help increase appropriate utilization.
- Avoid scheduled cesarean section prior to 39 weeks’ gestational age unless medically indicated.
- Preoperative recommendations for cesarean section include utilizing the Safe Surgery Checklist, using neuraxial anesthesia, avoiding prolonged preoperative fasting, pre-medicating with histamine type-2 receptor blockers and antacids, using anti-emetics to prevent intraoperative nausea, administering appropriate preoperative antibiotics within 60 minutes of skin incision, avoiding preoperative shaving, preparing the abdominal skin with alcohol-based preparation, cleansing the vagina preoperatively with iodine or chlorhexidine-based solution, draining the bladder prior to cesarean section, and maintaining maternal normothermia.
- Evidence-based cesarean section intraoperative techniques include using the Joel-Cohen skin incision, bluntly extending the hysterotomy in a cephalad–caudad direction, avoiding manual removal of the placenta, performing double-layer closure of the hysterotomy, avoiding routine intraperitoneal irrigation, avoiding routine peritoneal closure, reapproximating the subcutaneous tissue if \( \geq 2 \) cm, avoiding subcutaneous drain placement, performing skin closure with subcuticular stitches, considering using antibiotic-coated sutures, treating intraoperative post-spinal maternal hypotension with vasopressors, and infusing IV oxytocin for prevention of postpartum hemorrhage (PPH).
- Postoperative cesarean section recommendations include resuming regular diet within 4 hours of the procedure, removing urinary indwelling catheter within 12 hours post-cesarean section, encouraging early mobilization, maintaining optimal glycemic control for diabetic women, using pneumatic compression devices in all cases for thromboprophylaxis, using multimodal analgesia, removing the wound dressing at 24–48 hours with daily examination of the incision, considering negative pressure wound therapy for obese patients, avoiding routine postoperative antibiotic administration, using written discharge instructions,
and ensuring postoperative follow up within 3 weeks post-cesarean section.

- Plan cesarean section delivery (and cesarean section hysterectomy if required) at a tertiary-care center with multidisciplinary surgical expertise and access to a blood bank for patients with preoperative diagnosis of placenta accreta spectrum.
- Consider omission of a routine bladder flap at time of cesarean section as it has been shown to increase postoperative symptoms and risk of bladder injury.
- Consider placing indwelling urinary catheter for continuous bladder drainage for 14 days for cesarean section performed in setting of obstructed or prolonged labor.
- Repeat IV oxytocin for treatment of PPH, with addition of ergometrine or misoprostol if ongoing bleeding. Treatment with tranexamic acid 1000 mg IV should also be considered.
- Treat maternal severe hypertension ($\geq$160/110 mmHg) with an anti-hypertensive agent.

CONFLICTS OF INTEREST

The authors of this chapter declare that they have no interests that conflict with the contents of the chapter.
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Obstetrics - V12 - Operative obstetrics - Chapter - Evidence-Based Cesarean Section


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