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Current Commentary

The Case for Standardizing Cesarean Delivery Technique

Seeing the Forest for the Trees

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In this Commentary, we explain the case for a standardized cesarean delivery surgical technique. There are three strong arguments for a standardized approach to cesarean delivery, the most common major abdominal surgery performed in the world. First, standardization within institutions improves safety, efficiency, and effectiveness in health care delivery. Second, surgical training among obstetrics and gynecology residents would become more consistent across hospitals and regions, and proficiency in performing cesarean delivery measurable. Finally, standardization would strengthen future trials of cesarean delivery technique by minimizing the potential for aspects of the surgery which are not being studied to bias results. Before 2013, more than 155 randomized controlled trials, meta-analyses or systematic reviews were published comparing various aspects of cesarean delivery surgical technique. Since 2013, an additional 216 similar studies have strengthened those recommendations and offered evidence to recommend additional cesarean delivery techniques. However, this amount of cesarean delivery technique data creates a forest for the trees problem, making it difficult for a clinician to synthesize this volume of data. In response to this difficulty, we propose a comprehensive, evidence-based and standardized approach to cesarean delivery technique.

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Cesarean delivery is the most commonly performed major abdominal surgery in the world accounting for almost 30 million neonates born worldwide in 2015.[1] In 2019, approximately 1.1 million cesarean deliveries were performed in the United States.[2] Two previous systematic reviews summarized 155 randomized controlled trials (RCTs), meta-analyses or systematic reviews from 1960 to 2012 that addressed specific technical aspects of cesarean delivery.[3,4] Using identical search criteria, we located an additional 216 papers published from October 2012 through October 2019 addressing at least one aspect of cesarean delivery. This volume of published surgical technique data has created a forest for the trees problem, making it difficult for a typical clinician to formulate a comprehensive, evidence-based approach to the performance of cesarean delivery. The heterogeneity in surgical technique based on an individual surgeon's "preference" is problematic for institutions seeking efficiency in health care delivery, for resident trainees learning this important surgery and for researchers who study an aspect of the surgery in which differences in technique may bias results. The objective of this Commentary is to offer an evidence-based, standardized cesarean delivery surgical technique informed by the aforementioned 370 and up

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RCTs, meta-analyses and systematic reviews: one that both prioritizes the most up-to-date research and the value of standardization.

WHY STANDARDIZE CESAREAN DELIVERY SURGICAL TECHNIQUE?

Standardized approaches to clinical practice are consistently associated with improved outcomes. In the outpatient setting, protocols and checklists have reduced patient harm through increased standardization and communication.[5] The science of routinizing surgery remains in its infancy,[6,7] but may be particularly beneficial for high-volume procedures such as cesarean delivery. A prime example of these benefits is Shouldice Hospital, an inguinal hernia specialty hospital in Toronto, Ontario Canada. Atul Gawande, in his book *Complications,* described Shouldice's standardized approach to inguinal hernia repair which demonstrated a four-fold decrease in hernia recurrence relative to other Canadian hospitals.[6–8]

There is already strong evidence that standardizing certain aspects of cesarean delivery surgical technique is associated with less surgical site infection. Both Lemming et al and Kawakita et al reported a more than 50% reduction in surgical site infection when either four or nine aspects of cesarean delivery preparation or technique were standardized, respectively.[9,10] In a systematic review and meta-analysis of 44 studies, Martin et al[11] found similar surgical site infection reduction when preoperative antibiotic prophylaxis, vaginal preparation and spontaneous removal of the placenta were standardly performed. Carter et al[12] also demonstrated that evidence-based bundles were associated with reduced surgical site infection in a systematic review and meta-analysis. Interestingly, the techniques standardized varied among studies, suggesting that the act of bundling or standardization may independently contribute to improved outcomes rather than the specific techniques individually.

Since the previous systematic review by Dahlke et al in 2013, the CORONIS trial has reported short-term and long-term data for more than 15,000 women undergoing cesarean delivery randomized to three of five alternative surgical techniques.[4,13–15] There was no difference in outcomes related to cesarean delivery surgical technique including long-term outcomes such as subsequent uterine rupture (indicating that double layer uterine closure is not protective) or symptoms attributable to intra-abdominal adhesions (indicating that peritoneal closure is not protective). The authors suggest that in the absence of clinical benefit, considerations such as cost and time savings should dictate appropriate technique.[15] We concur wholeheartedly with this logic. Omitting steps with no benefit are just as important as including those with benefit and critical to establishing a standardized technique.

Recent guidelines for intraoperative care during cesarean delivery for enhanced recovery after surgery include eight standardized cesarean delivery techniques.[16] As outlined in the guideline and supportive of the premise of this commentary, a standardized approach that removes unjustified variability can independently improve safety, efficiency and effectiveness in a health care system.[16]

Regarding the benefit of a standardized surgical approach for resident training, consider the following example that likely rings true for any attending surgeon who supervises residents. A third-year obstetrics and gynecology resident and their attending are scrubbing in preparation for a scheduled cesarean delivery. While reviewing the patient's clinical history, the resident benignly asks, "Remind me how many layers you like to close the uterus and how do you close the skin again?" Anyone who teaches residents has probably had this exact experience. The resident was focusing on remembering the nuanced technique that their attending preferred, rather than the approach with the strongest evidence basis behind it. Given the fact that many residents operate with dozens of attending surgeons during their training, each with their own "preferences," it is clear that a more efficient and logical way to teach this common surgery is warranted and long overdue.

We acknowledge that not all cesarean deliveries are created equal and alterations to our standardized approach will be necessary in certain circumstances in which physician judgement and experience should play an important role. However, we believe that if a standardized approach becomes the primary technique taught to trainees, opportunities to highlight clinical scenarios that warrant modifications to this technique become strengthened. For example, a history of multiple prior cesarean deliveries or significant obesity may require modifications to abdominal entry techniques, and uterine exteriorization may not be possible when there is extensive intra-abdominal adhesive disease. However, a standardized cesarean delivery technique could positively influence resident education and performance. In a 2-year retrospective study of a standardized cesarean delivery surgical technique implemented at an academic obstetrics and gynecology residency program, Pallister et al[17] reported decreased incision to delivery and total operating time with similar perinatal and maternal outcomes after implementation of a standardized approach. When surveyed, second-year residents

had increased positive responses toward faculty time spent teaching surgical skills and fourth-year residents noted increased autonomy after standardization occurred.[17] For residents, a standardized approach may allow them to assess their improvement in the mastery of this common surgery, and for their supervisors, information to evaluate their progress by establishing reproducible, reliable, and measurable data regarding learning the procedure. For example, with a standardized approach, what is an appropriate incision to hysterotomy time, hysterotomy to delivery time, or time from delivery to uterine closure time for a trainee at a given level? Although these time intervals have been used as primary outcomes in numerous studies, the findings are often confounded owing to marked variation in surgical technique.

We recognize the audacity of proposing a standardized surgical approach to cesarean deliveries. In particular, why should one technique be employed over another if randomized trials do not demonstrate a clear benefit? It is worth noting that, in the past 7 years, there have been more RCTs published on this topic than in the previous 50 years combined. The trials vary tremendously in quality, sample size and primary outcomes, making it impossible for any clinician to synthesize best practices.

But an equally apposite question needs to be asked; What compels a surgeon to hold on to their "preference" in technique when there is no demonstrated benefit and instead adapt an approach that prioritizes standardization and improved resident education? We acknowledge the efficiency of habit relating to surgery, and recognize the difficulty of "unlearning" long-used surgical techniques.[18,19] However, we must also acknowledge the same habit-forming power of a standardized approach to cesarean delivery when training future surgeons. We believe the act of standardization, in and of itself, would provide high-quality and efficient resident training. As such, accounting for each individual surgeon's "preference" is both unnecessary and outdated.

Finally, we believe that a standardized approach to cesarean delivery would improve the quality of future trials by minimizing the potential for aspects of the surgery not being studied to bias results. Our standardized approach may serve as a template for such studies in the future. With this in mind, we have prioritized the following for each recommendation: 1) include techniques with high-quality evidence demonstrating benefit; 2) omit techniques if high-quality evidence suggests no benefit; and 3) if high-quality evidence is not available, inclusion or omission is based on consensus of the authors.

There are numerous ways to describe a standardized approach to cesarean delivery. One way to synthesize the data is to divide techniques into those that should be standardized by the surgeon and those that should be standardized at the institutional level. For purposes of this Commentary, we present all the techniques in order of their performance (or omission) that should be standardized by the surgeon. In addition, a checklist of techniques that should be standardized at the institution and surgeon level are included in Figure 1. In Appendix 1, available online at http://links.lww.com/AOG/C88, we review those aspects that should be standardized at the institutional level.

STANDARDIZED CESAREAN DELIVERY SURGICAL TECHNIQUE

Skin, Subcutaneous Tissue, Fascia, and Peritoneum Entry

Studies that report surgical approaches to abdominal entry were often associated with specific procedural techniques (Joel-Cohen, Misgav-Ladach, or Pfannenstiel methods). Although the location of the transverse skin incision between the Pfannenstiel and Joel-Cohen varies slightly, the primary difference in these techniques involves sharp compared with blunt dissection and expansion of tissue layers after the skin incision. Since the 2013 review, there have been six additional RCTs and one Cochrane Review on these techniques, with primary outcomes including operative time, postoperative analgesia requirements, febrile morbidity, blood loss, and duration of hospital stay.[4,20–27] Techniques that incorporated sharp dissection and blunt tissue expansion and entry were favored and supported by the Cochrane Review.

Recommendation: transverse skin incision 2–3 cm above the pubic symphysis, sharp subcutaneous and fascia dissection, blunt subcutaneous and fascia expansion with the omission of superior and inferior fascia dissection, and blunt peritoneal entry.

Bladder Flap Development

Previously, bladder flap development was not recommended with a moderate level of certainty.[4] Two additional RCTs and one systematic review strengthen this recommendation.[28–30] Omission of a bladder flap significantly reduces operative time as well as short-term and long-term bladder symptoms with no difference in intraoperative bladder injury rate.

Recommendation: omit bladder flap development.

Standardized Cesarean Delivery Surgical Technique Checklist	
Standardize by Surgeon	**Standardize by Institution**
☐ Abdominal entry: transverse, 2–3 cm above pubic symphysis, sharp subcutaneous and fascia dissection, omit superior and inferior fascia dissection, blunt subcutaneous and fascia expansion, blunt peritoneum entry	☐ Prophylactic antibiotics: preincision ampicillin or first-generation cephalosporin
☐ Bladder flap development: omit	☐ Add azithromycin if labor or ruptured membrances
☐ Uterine incision and expansion: 2–3 cm low transverse sharp incision, blunt entry, cephalad-caudad expansion	☐ Thromboprophylaxis: sequential compression devices before surgery
☐ Placenta removal: spontaneous	☐ Lateral tilt: omit
☐ Intrauterine wiping: perform only when placental membranes seen	☐ Warming interventions: standardized maternal active warming interventions
☐ Routine cervical dilation: omit	☐ Supplemental oxygen: omit
☐ Uterine repair: exteriorize	☐ Pre-operative enema: omit
☐ Uterine closure: single layer	☐ Skin preparation: chlorhexidine–alcohol
☐ Intraabdominal irrigation: omit	☐ Vaginal preparation: povidone–iodine if labor or ruptured membranes
☐ Peritoneal closure: omit	☐ Indwelling bladder catheter: preoperative placement, remove when feasible postoperatively
☐ Rectus muscle reapproximation: omit	☐ Incisional adhesive drapes: omit
☐ Glove change: omit	☐ Barrier retractors: omit
☐ Fascia closure: running, with delayed absorbable suture	☐ Uterine atony prevention: IV oxytocin 10–40 IU over 4–8 hours
☐ Subcutaneous tissue irrigation: perform	☐ Surgical needle type: blunt tip, if available
☐ Subcutaneous tissue closure: suture closure if ≥2 cm depth	☐ Wound dressing: standard postsurgical wound dressing
☐ Skin closure: subcuticular, absorbable monofilament suture	☐ Negative pressure wound therapy: omit

Fig. 1. Template checklist for standardized cesarean delivery technique. IV, intravenous; IU, international units.

Dahlke. Standardizing Cesarean Delivery Technique. Obstet Gynecol 2020.

Uterine Incision and Expansion

Sharp transverse uterine incision 2–3 cm, blunt uterine entry and cephalad-caudad expansion was previously recommended with a high level of certainty.[4] Two RCTs and four systematic reviews have since been published supporting this technique as it is associated with fewer unintended extensions.[31–36]

Recommendation: sharp 2–3-cm transverse uterine incision, blunt entry, cephalad-caudad expansion.

Placenta Removal

Spontaneous removal of the placenta was previously recommended with a high level of certainty.[4] Four additional RCTs have since been published.[37–40] The largest trial of 574 women demonstrated spontaneous placenta removal had a significant decrease in blood loss compared with manual removal.[37]

Recommendation: spontaneous placenta removal.

Intrauterine Wiping

Previously, there was insufficient evidence to favor intrauterine cleaning after placental delivery based on the lack of any RCTs.[4] One RCT of 206 women since did not demonstrate any benefit of this technique.[41]

Recommendation: perform intrauterine wiping only when placental membranes are seen.

Routine Cervical Dilation

Routine cervical dilation of the cervix was previously not recommended.[4] Four additional RCTs and one systematic review have been performed. Based on the systematic review, there remains no evidence of benefit with this technique.[42–46]

Recommendation: omit routine cervical dilation.

Uterine Repair: in Situ or Exteriorized

An additional three RCTs and one systematic review have been published, adding to the prior 14 previous RCTs or systematic reviews.[4,13,47–49] Similar to prior studies, there may be benefit to either exteriorization or in situ repair depending on the outcome of interest. In the most recent systematic review by Zaphiratos et al,[48] exteriorization appeared to reduce blood loss. Previous RCTs and reviews demonstrated benefit of in situ repair with regard to patient nausea, vomiting and resumption of bowel motility postoperatively. There were no short-term or long-term outcome differences between groups in the CORONIS trial.[13–15] Given the likely blood loss reduction, ability to medically mitigate patient symptoms, and improved inspection of the adnexa, uterine exteriorization is recommended.

Recommendation: uterine exteriorization during repair.

Uterine Closure

Optimal uterine closure remains one of the most studied and controversial aspects of cesarean delivery. Eleven additional RCTs and four systematic reviews have been performed since the previous review.[4,13–15,36,50–61] Two RCTs were also performed comparing barbed suture compared with standard suture for uterine closure.[62,63] In addition to single- compared with two-layer closure, a distinction is made in some RCTs regarding locked or unlocked suture technique. Primary outcomes vary between operating time, blood loss, and postpartum ultrasound measurement of the residual myometrial thickness. These studies suggest that two-layer closure, in particular when the first layer is closed in an unlocked fashion, likely results in the thickest residual myometrial thickness, a finding not clearly associated with clinical outcomes.

The strongest clinically relevant data regarding single- or two-layer closure are from the 3-year follow-up of the CORONIS trial.[15] Of the original 9,200 women randomized to single- or double-layer closure, approximately 1,600 women in each group had subsequent viable pregnancies within 3 years. In those with single-layer closure of the uterus, only 5 of 1,610 experienced uterine rupture or scar dehiscence compared with 4 of 1,624 in the two-layer closure group. Importantly, 3 of 674 in the single layer group and 4 of 680 in the double layer arm experienced this outcome while in labor. Placenta previa or morbidly adherent placenta were both similarly rare and not significantly different between groups.[13–15]

Recommendation: single-layer uterine closure.

Intra-abdominal Irrigation

Routine intra-abdominal irrigation was not recommended based on the findings of two RCTs.[4] Since then, one RCT and one systematic review strengthen these recommendations. Intra-abdominal irrigation has consistently been shown to increase intraoperative and postoperative nausea, increased antiemetics use, and no reduction in infection rate.[64,65]

Recommendation: omit intra-abdominal irrigation.

Peritoneal Closure

Closure compared with nonclosure of the parietal peritoneum was one of the most studied technical steps in the previous review with no clear benefit of either surgical approach.[4] One RCT and one systematic review have been performed since then and it was also a technical step included in the CORONIS trial.[13–15,66,67] There was no difference in short-term or long-term outcomes between groups in this trial and no clear benefit demonstrated in the Cochrane Review.[66,67]

Recommendation: omit peritoneal closure.

Rectus Muscle Reapproximation

Compared with other technical aspects, there is a paucity of RCTs that address reapproximation of the rectus muscle. In the prior review, there were no identified RCTs that addressed this step.[4] One RCT has since been published and rectus muscle reapproximation was associated with increased postoperative pain and analgesic requirements.[68]

Recommendation: omit rectus muscle reapproximation.

Glove Change

Previously, intraoperative glove change was not recommended with moderate certainty.[4] Although one recent RCT reported a decreased risk of a composite wound complication with glove change, three previous trials found no benefit to glove change, including the largest (N=760, relative risk [RR] for endometritis 1.0, 95% CI 0.79–1.3).[69–72] Given this inconsistent and conflicting data, routine glove change is not recommended.

Recommendation: omit routine glove change.

Fascia Closure

One RCT addressing suture type (nonabsorbable compared with delayed-absorbable) has been performed since the previous review, demonstrating less chronic incisional pain with delayed-absorbable suture.[4,73]

Recommendation: continuous with delayed absorbable suture.

Subcutaneous Tissue Irrigation

Subcutaneous tissue irrigation remains under studied compared with other aspects of cesarean delivery. One RCT of 185 women demonstrated no difference in surgical site infection but less hematoma and seroma formation in those who had subcutaneous saline irrigation.[74]

Recommendation: perform subcutaneous tissue irrigation.

Subcutaneous Tissue Closure

Subcutaneous tissue closure without drain placement was previously recommended based on 11 RCTs or systematic reviews if tissue depth was 2 cm or greater.[4] Two additional RCTs and a meta-analysis since supports re-approximating this tissue layer as previously recommended.[75–77]

Recommendation: suture closure if 2 cm depth or greater.

Skin Closure

Previously, skin closure with either staples or subcuticular suture was recommended based on nine RCTs or systematic reviews.[4] Since then, 19 RCTs and one systematic review have been performed addressing skin closure techniques.[78–97] These trials range in a variety of comparisons, including subcuticular suture compared with staples, different staple removal times, subcuticular suture compared with subcuticular staples, interrupted compared with running subcuticular suture, monofilament compared with multifilament suture, or subcuticular suture compared with glue. In a meta-analysis of 12 RCTs, subcuticular suture closure significantly reduced wound morbidity with no difference in pain, patient satisfaction, or cosmesis.[92] In trials that included women with obesity, subcuticular suture was superior to staples.[84,93] One trial demonstrated that monofilament suture reduced wound complications compared with multifilament suture.[94]

Recommendation: subcuticular, absorbable monofilament suture.

CONCLUSION

In this Commentary, we propose a standardized cesarean delivery surgical technique and provide the rationale for inclusion of each technical aspect informed by an updated systematic review of the literature. An evidence-based, standardized approach would benefit institutions by improving safety and efficiency, benefit resident training by providing consistency and improved teaching, and strengthen future trials of cesarean delivery technique. In Figure 1, we have provided a template for a checklist for our standardized approach that may prove useful. In summary, we believe now is the time for all stakeholders, including attending surgeons, obstetrics and gynecology residents, and institutional policymakers, to adopt an evidence-based, standardized approach to the most common abdominal surgery performed in the world.

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