Neuraxial Anesthesia During Cesarean Delivery for Placenta Previa With Suspected Morbidly Adherent Placenta: A Retrospective Analysis

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BACKGROUND: General anesthesia (GA) is often selected for cesarean deliveries (CD) with placenta previa and suspected morbidly adherent placenta (MAP) due to increased risk of hemorrhage and hysterectomy. We reviewed maternal outcomes and risk factors for conversion to GA in a cohort of patients undergoing CD and hysterectomy under neuraxial anesthesia (NA).

METHODS: We performed a single-center, retrospective cohort study of parturients undergoing nonemergent CD for placenta previa with suspected MAP from 1997 to 2015. Patients were classified according to whether they received GA, NA, or intraoperative conversion from NA to GA. The primary outcome measure was postoperative acuity, defined as the need for intensive care unit admission, arterial embolization, reoperation, or ongoing transfusion with ≥3 units packed red blood cells. We additionally identified variables positively associated with intraoperative conversion from NA to GA during hysterectomy. Confounding was controlled with logistic regression models.

RESULTS: Of 129 patients undergoing nonemergent CD for placenta previa with suspected MAP, 122 (95%) received NA as the primary anesthetic. NA was selected in the majority of patients with a body mass index ≥40 kg/m² (9 of 10, 90%), a history of ≥3 prior CDs (18 of 20, 90%), suspected placenta increta or percreta (29 of 35, 83%), and Mallampati classification ≥3 (19 of 21, 90%). Of 72 patients with NA at the time of delivery who required hysterectomy, 15 (21%) required conversion to GA intraoperatively. Converted patients had a higher rate of major packed red blood cell transfusion (60% vs 25%; P = .01), with similar rates of massive transfusion (9% vs 7%; P = .1). Converted patients also had a higher incidence of postoperative acuity (47% vs 4%; P < .0001), including 5 intensive care unit admissions for airway management after large-volume resuscitation. After adjusting for multiple confounders, the only independent predictors of conversion among hysterectomy patients were longer surgical duration (adjusted odds ratio 1.54, 95% CI, 1.01–2.42) and a history of ≥3 prior CDs (adjusted odds ratio, 6.45; 95% CI, 1.12–45.03).

CONCLUSIONS: NA was applied to and successfully used in the majority of patients with suspected MAP. Our findings support selective conversion to GA during hysterectomy in these patients, focusing on those with the highest levels of surgical complexity. (Anesth Analg XXX;XXX:00–00)

KEY POINTS

- **Question:** Can patients with placenta previa and suspected morbidly adherent placenta be safely managed under neuraxial anesthesia only?
- **Findings:** The majority of patients receiving cesarean delivery and hysterectomy completed their surgery with neuraxial anesthesia alone, even in cases of major blood loss and high risk of surgical complexity.
- **Meaning:** Neuraxial anesthesia can be successfully used in the majority of patients receiving cesarean delivery complicated by placenta previa and morbidly adherent placenta.

Morbidly adherent placenta (MAP), the pathologic attachment of the placenta to the uterine myometrium, occurs in approximately 1 in 500 pregnancies and is associated with increased risk of severe postpartum hemorrhage (PPH), hysterectomy, and admission to the intensive care unit (ICU). The risk of MAP is highest in patients with placenta previa, particularly for those with a history of cesarean delivery (CD). In
addition, the coincident state of placenta previa and MAP is associated with an increased incidence of complications compared to placenta previa alone. Further classification of MAP into placenta accreta, increta, and percreta denotes increasing invasion depth and morbidity.

While routine CDs are commonly performed under neuraxial anesthesia (NA), various studies describing the anesthetic management of CD in patients at high risk for PPH involve general anesthesia (GA) either as the primary anesthetic or as a conversion from NA after delivery. GA has been advocated to facilitate large-volume resuscitation while avoiding sympathectomy-induced hypotension, an uncontrolled airway, and an indwelling neuraxial catheter in conjunction with potentially altered coagulation. However, small studies have documented the successful use of NA for management of CD in patients at greater risk for PPH or who require hysterectomy. Larger studies are needed to further evaluate outcomes of NA for the management of suspected MAP.

Here, we report a single-center retrospective analysis of the mode of anesthesia for cases of nonemergent CD with placenta previa and suspected MAP. We reviewed the outcomes and maternal morbidity with planned NA in a cohort of patients with suspected MAP, and identified risk factors for nonelective conversion to GA. We hypothesized that NA could be safely maintained for the majority of patients undergoing CD for this indication.

METHODS

Study Design

This retrospective cohort study was approved by the institutional review board at Partners Healthcare and written informed consent was waived. We collected data on all deliveries occurring at Brigham and Women’s Hospital (BWH) in Boston, MA, between January 1997 and December 2015, and included patients with placenta previa and radiographic suspicion for MAP (including accreta, increta, and percreta). Patients with emergent deliveries, defined as a CD for maternal or fetal instability occurring within 1 hour of delivery, were excluded. This article adheres to the applicable STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) guidelines.

Detailed demographic, radiologic, obstetric, surgical, and anesthetic data were collected from the electronic and paper medical records. Written radiologic reports were reviewed for all patients, including ultrasound and magnetic resonance imaging when performed. Placenta previa at delivery was defined as the placental edge coming within 2 cm of the cervical os. Patients were identified for the study by the presence of any radiographic report citing suspicion for placenta accreta. Further characterization as suspected placenta accreta, increta, or percreta was taken directly from the radiology report. If the radiology report stated “cannot rule out” accreta with no additional diagnostic certainty, this was classified as “low suspicion.” Likewise, if the radiology report stated “creta,” this was included, but not categorized. Pathologic diagnosis of no invasion, accreta, increta, or percreta was determined from the written pathology report.

While the anesthesia management of patients with placenta previa and suspected MAP is not standardized at BWH, NA is the most prevalent choice. Pre-, intra-, and postoperative anesthetic techniques and surgical planning for these cases are left to the discretion of individual providers. BWH is a tertiary academic medical center and the labor and delivery unit can provide temporary maternal intensive care, including telemetry and invasive monitoring with an arterial line; the unit does not care for patients who are intubated or who require a vasopressor infusion.

Recorded Variables

The primary anesthetic was defined as the mode of anesthesia intended at the time of surgical incision for CD. For the purposes of this study, the definition of GA required endotracheal intubation; no patient received GA with a laryngeal mask airway. Patients who received NA for pre-CD ureteral stenting and/or internal iliac arterial catheterization and then planned GA for the CD, and those who had GA with NA used only for postoperative pain control were recorded as primary GA. The primary NA group was composed of patients whose intended anesthetic was NA. This group was subdivided according to whether the conversion occurred before (early neuraxial failure) or after (NA-to-GA) delivery of the neonate(s). The NA-only group of patients received NA for the entirety of the case. Indication for the use of GA was derived from the anesthetic record. In cases where an indication was not specified and there was no clear medical indication for GA, the term “elective” was used. The induction method (eg, rapid sequence intubation) was not recorded consistently in the anesthesia record, so was omitted from analysis.

Body mass index (BMI) was calculated from the reported height and weight on the day of surgery. Surgical duration was defined as the time from CD skin incision to skin closure. The first 30 minutes of GA was defined as the 30 minutes immediately after induction of GA. Apgar scores are reported per delivery; in the case of multiple gestations, if any neonate had a 1- or 5-minute Apgar score <7, then the outcome was recorded for the pregnancy. Cases of intrauterine fetal demise were excluded.

Intravenous (IV) supplemental sedation in patients receiving NA only was recorded during CD and any pre-CD procedures such as neuraxial placement, ureteral stenting, or interventional radiology procedures. No patient received an inhaled anesthetic to supplement NA. Sedation dosage for patients receiving NA only was determined by calculating the cumulative medication dose administered during CD using the following scale: Low-dose sedation included any combination of midazolam ≤4 mg, fentanyl ≤200 µg, hydromorphone ≤1 mg, morphine ≤2 mg, or ketamine ≤30 mg. Medium-dose sedation included any combination of midazolam >4 mg, fentanyl >200 µg, or ketamine 30–50 mg. High-dose sedation included any propofol or ketamine >50 mg.

Phenylephrine equivalents were calculated using the following equation: phenylephrine (µg) + [ephedrine (µg) ÷ 81.2]. No patient received a vasopressor medication other than phenylephrine or ephedrine. When a phenylephrine infusion was charted in the anesthesia record, but not the dose that was infused, then vasopressor use was recorded as a categorical variable.

A cryoprecipitate unit was defined as a pool from 10 donors. A platelet unit was defined as a pool from 6 donors. Administration of a cell salvage volume of 250 mL was
considered equivalent to receiving 1 allogeneic packed red blood cell (PRBC) unit. The intraoperative variable “total products” represents the sum total units of any blood product administered in the intraoperative period. Second-line uterotonicss were defined as any intraoperative administration of methylergonovine, 15-methyl-PGF2α, or misoprostol.

The primary outcome measure was postoperative acuity, defined as the need for ICU admission in the 24 hours after surgery, postoperative uterine arterial embolization, reoperation, or ongoing transfusion with ≥3 units PRBC. We additionally identified variables positively associated with intraoperative conversion from NA to GA during hysterectomy. Additional outcome measures included incidence of intraoperative estimated blood loss (EBL) >1500 mL, major (≥4 U PRBC) and massive (≥10 U PRBC) intraoperative transfusion, maternal postpartum length of stay, surgical duration, and postoperative complication rate. The latter included any bowel, renal, or neurologic complications, venous thromboembolism, wound infection or breakdown, pelvic hematoma, or delayed (>24 hours postoperatively) PPH. We additionally assessed clinical variables that were associated with conversion from NA to GA during CD with hysterectomy.

**Statistical Analysis**

Statistical analysis was conducted using SAS version 9.4 software. Continuous variables were described with median (range) because none were normally distributed. Categorical variables were compared with Fisher exact tests, and odds ratios (OR) with 95% CI were calculated for our primary study questions. Continuous variables were analyzed with Wilcoxon rank-sum tests. NA-only and NA-to-GA patients were compared in terms of conversion risk factors, major transfusion, and postoperative acuity using logistic regression models. Potential conversion risk factors included any preoperative or intraoperative factors that varied between the 2 groups with a P value ≤.2. These were combined in a single model, which was then adjusted for confounders. When 2 highly correlated variables met inclusion criteria, the 1 with the lower P value was used in the model. To control for confounding, potential confounders were tested individually in multivariable logistic regression models, and any variable that shifted the primary OR by 10% or more was retained in the model. The following variables were tested as potential confounders: maternal age (years), parity, gestational age (weeks), BMI (kg/m²), Caucasian vs. non-Caucasian race, presence of uterine fibroids or gestational hypertension/preclampsia, preoperative suspicion of increta or percreta, history of ≥3 CDs, preoperative ureteral stenting or interventional radiology, bleeding as the indication for CD, vertical versus Pfannenstiel skin incision, and attempted placental removal during the CD. Final ORs were calculated with exact conditional logistic regressions to account for small numbers of patients in the comparisons. All results with a P value <.05 with 2-tailed analyses were considered significant.

**RESULTS**

**Mode of Anesthesia**

We identified 137 patients who underwent CD for placenta previa and suspected MAP during the study period, of whom 8 received surgery emergently and were excluded from further analysis (Figure). Of the 129 remaining CDs, GA was the primary anesthetic in 7 cases (5%) and NA in 122 (95%). Of the primary NA cases, 5 (4%) were converted to GA before delivery for failure to achieve adequate surgical anesthesia (early NA failure group) and 15 (12%) were converted to GA after delivery (NA-to-GA group). The remaining 102 (84%, 79% of overall cohort) received NA only (NA-only group). The use of GA was elective in the 7 primary GA cases, none of whom had a documented preoperative risk factor for difficult airway.

**Figure.** Anesthetic management of CD complicated by placenta previa and suspected morbidly adherent placenta. CD indicates cesarean delivery; early NA failure, intraoperative conversion from NA to GA before delivery; GA, general anesthesia; NA, neuraxial anesthesia; NA-to-GA, intraoperative conversion from NA to GA after delivery; NA-only, NA utilized for the duration of CD.
Three cases of difficult intubation were noted: 1 in the early NA failure group (unable to intubate, necessitating emergence and awake fiberoptic intubation) and 2 in the NA-to-GA group (video laryngoscopy necessary for intubation; intubation over a gum elastic bougie).

To evaluate the amount of supplemental sedation, we recorded the use of supplemental IV medications and doses administered in the 102 patients in the NA-only group (Supplemental Digital Content 1, Table, http://links.lww.com/AA/A286). Midazolam (n = 52, 51%; median dose 2 mg, range 1–16 mg) and fentanyl (n = 48, 47%; median dose 100 µg, range 25–500 µg) were the most common supplemental agents administered. The majority of patients receiving NA only were administered either no sedation (38%) or low-dose sedation (41%) during CD (Supplemental Digital Content 2, Table, http://links.lww.com/AA/C287). There were no instances of pulmonary aspiration.

### Primary Anesthetic

Demographic data of patients who received primary GA or primary NA are detailed in Table 1. NA was the planned anesthetic modality in the majority of patients, including those with preoperative risk factors for higher surgical complexity such as BMI ≥40 kg/m² (9/10, 90%), history of ≥3 CDs (18/20, 90%), and uterine fibroids (17/19, 89%). Of note, though 6 of 7 patients with primary GA had a suspected placenta percreta, the majority of patients with radiographic suspicion for placenta increta or percreta (29/35, 83%) received an intended initial neuraxial anesthetic. Of the patients who received a final pathologic diagnosis of placenta increta or percreta, 53 of 58 (91%) had received primary NA. Additionally, the majority of patients (19/21, 90%) with a Mallampati classification ≥3 had planned NA.

#### Intraoperative Conversion From NA to GA

Of the 5 patients who underwent early conversion to GA for neuraxial failure, 4 were before skin incision and 1 was after skin incision but before delivery. An additional 15 patients (12%) underwent conversion to GA after delivery. Reasons for postdelivery intraoperative NA-to-GA conversion included resuscitation (n = 7), pain (n = 6), enhanced surgical exposure (n = 1), and elective (n = 1).

The performance of a hysterectomy can often prompt the anesthesia provider to convert from NA to GA. Of 117 patients who remained under NA at the time of delivery, 72 underwent hysterectomy and of these, 15 (21%) were converted to GA (Figure). We next evaluated associations with NA-to-GA conversion in those receiving hysterectomies (Table 2). Compared to the NA-only population, conversion from NA to GA was associated with a history of ≥3 CDs (38% vs 12%; P = .02), longer surgical duration (4.0 vs 2.6 hours; P < .01), and receipt of ≥4 U PRBC intraoperatively (60% vs 25%; P = .01), but not receipt of ≥10 U PRBC (9% vs 7%; P = 1.0). Preoperative suspicion for placenta increta or percreta (P = .76), BMI at delivery (P = .75), type of NA (P = .48), type of skin incision (P = 1.0), and EBL (P = .05) were not different between groups. Presence of uterine fibroids (P = .05) was not statistically different between groups, but met inclusion criteria as a potential risk factor for conversion. While EBL and parity also satisfied criteria based on P value, these were not included due to the use of other highly-correlated variables (major PRBC transfusion and number of prior CDs).

Compared to the NA-to-GA group, the patients receiving NA only had a lower incidence of postoperative acuity (4% vs 47%; P < .0001) with a similar rate of postoperative complications (11% vs 7%; P = 1.0; Table 2). Two of 57 (4%) NA-only patients were admitted to the ICU: 1 electively after large-volume resuscitation and 1 who remained intubated due to concern for airway swelling after large-volume resuscitation during emergent reoperation under GA. All 5 ICU admissions in the NA-to-GA group remained intubated postoperatively due to concern for airway swelling after large-volume resuscitation, 2 in the setting of difficult intubation.

We applied logistic regression modeling to determine independent predictors of postdelivery NA-to-GA conversion (Table 3). After including potential conversion risk factors and testing for other potential confounders (with BMI and preoperative suspicion for increta/percreta retained in the model), only a history of ≥3 CDs (adjusted OR, 6.45; 95% CI, 1.12–45.03) and prolonged surgical duration (adjusted OR, 1.54; 95% CI, 1.01–2.42, per 30-minute time block) were significant independent predictors.

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**Table 1. Patient Characteristics**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Primary GA n = 7</th>
<th>Primary NA n = 122</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal age, y</td>
<td>35.4 (23.4–39.6)</td>
<td>36.0 (23.3–51.3)</td>
</tr>
<tr>
<td>Parity</td>
<td>3 (2–4)</td>
<td>1 (0–6)</td>
</tr>
<tr>
<td>Gestational age, wk</td>
<td>35.9 (28.1–36.9)</td>
<td>36.0 (25.0–38.9)</td>
</tr>
<tr>
<td>BMI at delivery, kg/m²</td>
<td>32 (29–41)</td>
<td>28 (21–54)</td>
</tr>
<tr>
<td>BMI ≥40, kg/m²</td>
<td>1 (14%)</td>
<td>9 (7%)</td>
</tr>
<tr>
<td>≥3 prior CD</td>
<td>2 (29%)</td>
<td>18 (15%)</td>
</tr>
<tr>
<td>MP classification ≥3</td>
<td>2 (29%)</td>
<td>19 (16%)</td>
</tr>
<tr>
<td>Caucasian race</td>
<td>4 (57%)</td>
<td>81 (66%)</td>
</tr>
<tr>
<td>Multiple gestation</td>
<td>0 (0%)</td>
<td>4 (3%)</td>
</tr>
<tr>
<td>Uterine fibroids</td>
<td>2 (29%)</td>
<td>17 (14%)</td>
</tr>
<tr>
<td>Gestational HTN or preeclampsia</td>
<td>0 (0%)</td>
<td>7 (6%)</td>
</tr>
</tbody>
</table>

**Suspected placental invasion**

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Primary GA</th>
<th>Primary NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accreta</td>
<td>0 (0%)</td>
<td>79 (66%)</td>
</tr>
<tr>
<td>Increta</td>
<td>0 (0%)</td>
<td>7 (6%)</td>
</tr>
<tr>
<td>Percreta</td>
<td>6 (86%)</td>
<td>22 (18%)</td>
</tr>
<tr>
<td>Low suspicion</td>
<td>1 (14%)</td>
<td>12 (10%)</td>
</tr>
<tr>
<td>Suspected increta/percreta</td>
<td>6 (86%)</td>
<td>29 (24%)</td>
</tr>
<tr>
<td>Preoperative ureteral stents</td>
<td>3 (43%)</td>
<td>25 (20%)</td>
</tr>
<tr>
<td>Preoperative IR</td>
<td>4 (57%)</td>
<td>23 (19%)</td>
</tr>
<tr>
<td>Bleeding as indication for CD</td>
<td>2 (29%)</td>
<td>17 (14%)</td>
</tr>
<tr>
<td>Vertical skin incision</td>
<td>7 (100%)</td>
<td>87 (71%)</td>
</tr>
<tr>
<td>Apgar score</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-min &lt; 7</td>
<td>4 (57%)</td>
<td>25 (20%)</td>
</tr>
<tr>
<td>5-min &lt; 7</td>
<td>2 (29%)</td>
<td>9 (7%)</td>
</tr>
<tr>
<td>Attempted placental removal</td>
<td>3 (43%)</td>
<td>73 (60%)</td>
</tr>
<tr>
<td>Hysterectomy</td>
<td>7 (100%)</td>
<td>76 (62%)</td>
</tr>
<tr>
<td>Pathologic diagnosis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No invasion</td>
<td>0 (0%)</td>
<td>39 (35%)</td>
</tr>
<tr>
<td>Accreta</td>
<td>2 (29%)</td>
<td>21 (19%)</td>
</tr>
<tr>
<td>Increta</td>
<td>3 (43%)</td>
<td>28 (25%)</td>
</tr>
<tr>
<td>Percreta</td>
<td>2 (29%)</td>
<td>25 (22%)</td>
</tr>
</tbody>
</table>

Data shown as median (range) or n (%).

Abbreviations: BMI, body mass index; CD, cesarean delivery; GA, general anesthesia; HTN, hypertension; IR, interventional radiology; MP, Mallampati; NA, neuraxial anesthesia.

*2 includes only subjects who had a pathologic specimen sent at delivery. This includes 7/7 (100%) of those with primary GA, 113/122 (93%) with primary NA.

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Hemodynamic Changes After GA Induction

We next approximated hemodynamic stability immediately after GA induction using vasopressor administration as a surrogate marker of maternal hypotension (Table 4). Vasopressors (phenylephrine and/or ephedrine) were administered in the first 30 minutes after GA induction in 3/7 (43%) cases of primary GA, 3/5 (60%) cases of early NA failure, and 9/15 (60%) cases of NA-to-GA cases. Within the groups that underwent conversion, immediate postinduction vasopressors were administered in 6 of 7 (86%) patients converted for resuscitation and in 6 of 13 (46%) who were converted for nonresuscitation purposes. Phenylephrine equivalents administered in the first 30 minutes after GA induction varied widely within each group: Primary GA, 0–653 µg; early NA failure, 0–486 µg; NA-to-GA, 0–1320 µg, though data were incomplete for some patients. Patients in the NA-to-GA group underwent conversion to GA a median of 71 minutes (range 8–166...
10%–45% range reported by others,15,17,18,21 we observed
tection, and management of acidosis. Consistent with the
stimulus to convert to GA due to the anticipation of mas-
tive decision to perform gravid hysterectomy can be the
data imply that NA can be successfully used in patients
≥
In our cohort, most patients with preoperative risk fac-
ties support the safety and benefits of NA as the primary
anesthetic for CD with high risk for PPH and large-volume
resuscitation.
Application of an intended NA-only technique may
avoid maternal complications of GA, including difficult
and failed intubation,23,24 pulmonary aspiration,23,24 intraop-
erative awareness,26 inferior postoperative pain control,26,27
development of chronic pain,26 and increased maternal mor-
tality.29 In addition, retrospective analyses of CD30 and CD
for placenta previa31,32 demonstrated lower EBL and trans-
fusion requirements for NA compared to GA, although
another study showed no difference.13 These studies, how-
ever, may reflect a high level of selection bias. In a small
randomized study comparing NA and GA for CD for pla-
centa previa, EBL was similar for both treatments, although
transfusion requirement was lower in the NA group.33
Furthermore, ability to maintain intraoperative blood pres-
dure during NA was successful in the majority of CDs for
previa, even in the setting of hemorrhage.32,33 Regarding
neonatal outcomes, the incidence of neonatal depression
was decreased or similar, but not increased, when NA was
utilized compared to GA.34,35 Finally, breastfeeding was ini-
tiated earlier and maintained longer with NA.36 These stud-
ies support the safety and benefits of NA as the primary
anesthetic for CD with high risk for PPH and large-volume
resuscitation.

A strength of this study is the cohort size, which allowed
us to evaluate maternal and surgical characteristics, opera-
tive outcomes, and risk factors for conversion from NA to
GA during CD with hysterectomy. Furthermore, by focusing
our retrospective study on cases of suspected MAP, rather
than pathologically confirmed MAP, we examined a clini-
cally realistic cohort of patients. Importantly, this accounts
for the 12% false-positive rate for radiologically-diagnosed
accrēta.37

Our analysis is limited by its retrospective, nonran-
domized design, allowing for unrecognized confounding.
Including patients with a questionable preoperative MAP
diagnosis may bias our results toward favorable outcomes;
though by restricting our morbidity analyses to those
undergoing hysterectomy, we have minimized misclassifi-
cation bias. The limited number of GA patients precluded
statistical comparisons of primary NA and GA and conclu-
sions regarding the superiority of 1 anesthetic modality over
the other. Likewise, incomplete data and low overall num-
bers precluded a quantitative comparison of vasopressor
use between groups; categorical data for vasopressor use
were recorded; however, its utility may be limited because
wide variations in dosing were observed. We were unable
to determine whether the elective use of GA was provider-
or patient-driven, and if the availability of supplemental
sedation factored into that choice. Finally, we were unable
to accrue and report data on important maternal outcomes
such as intra- and postoperative nausea and vomiting inci-
dence, pain scores, breastfeeding rates, and patient satisfac-
tion, areas that prospective studies should address.

Retrospective studies comparing NA-to-GA out-
ces outcomes risk misclassification bias if patients with NA
also received IV supplemental sedation in amounts that
could approach typical doses used for GA, albeit with-
out definitive airway management. Assessing sedation
level with a categorical scale based on the total dose of
supplemental medications used during CD, we found
that the majority of patients in our analysis received no

Table 3. Variables Associated With Postdelivery
Conversion From NA to GA+

<table>
<thead>
<tr>
<th>Variable</th>
<th>OR (95% CI)</th>
<th>aOR (95% CI)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uterine fibroids</td>
<td>4.82 (1.04–22.26)</td>
<td>3.84 (0.38–36.73)</td>
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<tr>
<td>≥3 prior CD</td>
<td>4.76 (1.30–17.49)</td>
<td>6.45 (1.12–45.03)</td>
</tr>
<tr>
<td>≥4 U PRBC intraoperative</td>
<td>4.61 (1.39–15.24)</td>
<td>3.13 (0.16–11.02)</td>
</tr>
<tr>
<td>Surgical duration (per 30-min time interval)</td>
<td>1.52 (1.17–1.99)</td>
<td>1.54 (1.01–2.42)</td>
</tr>
</tbody>
</table>

Abbreviations: OR, odds ratio; aOR, adjusted odds ratio; CD, cesarean delivery; GA, general anesthe-
ia; NA, neuraxial anesthesia; PRBC, packed red blood cells; U, units.

*Logistic regression models are controlled for body mass index and
preoperative suspicion for increta or percreta.

Reported as exact ORs.

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### Table 4. Anesthetic and Operative Course Details of Patients Receiving GA

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Neuraxial Type</th>
<th>Indication for GA</th>
<th>Time Between Delivery and GA Induction, min</th>
<th>GA Induction Agent, Dose, mg/kg</th>
<th>GA Maintenance Agent</th>
<th>Intubation Method</th>
<th>Difficult Airway (Yes/No)</th>
<th>Pre-GA Induction EBL/L</th>
<th>PRBC/FFP Administered Pre-GA Induction, U/U</th>
<th>Vasopressor Administered in First 30 min of GA (Yes/No)</th>
<th>Phenylephrine Equivalents in First 30 min of GA, μg</th>
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</thead>
<tbody>
<tr>
<td>Primary GA (n = 7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>N/A</td>
<td>Elective</td>
<td>Preincision</td>
<td>T.2.8</td>
<td>Iso/N₂O</td>
<td>DL</td>
<td>No</td>
<td>0/0.3</td>
<td>0/0</td>
<td>No</td>
<td>0</td>
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<tr>
<td>2</td>
<td>N/A</td>
<td>Elective</td>
<td>Preincision</td>
<td>T.4.0</td>
<td>Iso/N₂O</td>
<td>DL</td>
<td>No</td>
<td>0/3.0</td>
<td>0/0</td>
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<td>0</td>
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<tr>
<td>3</td>
<td>N/A</td>
<td>Elective</td>
<td>Preincision</td>
<td>T.4.5</td>
<td>Sevo/N₂O</td>
<td>DL</td>
<td>No</td>
<td>0/1.5</td>
<td>0/0</td>
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Abbreviations: CS, continuous spinal; CSE, combined spinal-epidural; Des, desflurane; DL, direct laryngoscopy; E, epidural; EBL, estimated blood loss; FFP, fresh frozen plasma; GA, general anesthesia; ID, incomplete data; Iso, isoflurane; K, ketamine; N₂O, nitrous oxide; NA, neuraxial anesthesia; N/A, not applicable; NR, not recorded; Propofol; PRBC, packed red blood cells; S, spinal; Sevo, sevoflurane; T, thiopental; U, units; VL, video laryngoscopy.

**a** NA was attempted, but was not successfully placed due to technical reasons.

**b** A CSE was intended, but the catheter was not able to be inserted.
or low-dose sedation. For the relatively few patients who received ketamine or propofol, the total dose of these medications divided over the duration of surgery makes it unlikely that these NA-only classified patients actually received GA. Awareness of the risk of pulmonary aspiration of gastric contents is paramount when administering anesthetics to pregnant patients with unsecured airways. Low-dose sedation or GA with a laryngeal mask airway, however, appears not to be associated with pulmonary aspiration in properly fasted patients undergoing CD. 38,39

We acknowledge that our favorable outcomes may not be generalized to all practice environments, and we cannot determine how our results compare to centers that electively convert from NA to GA at the time of hysterectomy. These findings from our tertiary-care facility with 24-hour access to multiple obstetric anesthesia providers may not extrapolate to centers with more limited resources. Furthermore, our labor and delivery unit is capable of invasive monitoring for nonintubated patients, likely contributing to a lower ICU admission rate. While anesthetic choice should be individualized to a center’s capabilities, those with fewer resources may consider patient referral to a specialized center with similar tertiary-care resource levels. 40,41

The safety of conversion from NA to GA for CD has been demonstrated. 42 However, the 3 difficult intubations encountered here highlight the controversy surrounding the unsecured maternal airway during CD with increased massive PPH risk. The risk of encountering a difficult airway may be minimized by keeping the majority of patients under NA, as long as adequate resources are available in case intraoperative intubation is required. Conversely, those in limited-resource settings who wish to secure the maternal airway early may select patients with anticipated surgical complexity or a difficult airway. If applying an NA-only technique, it would be prudent to have the patient optimally positioned throughout the entire procedure and have difficult airway equipment immediately available.

In conclusion, given the successful application of an NA-only anesthetic technique, our data suggest that elective use of primary or converted GA may be unnecessary in the majority of patients undergoing nonemergent CD with placenta previa and suspected MAP. For those who wish to avoid intraoperative conversion from NA to GA, restricting primary GA to those patients with the highest surgical complexity, and waiting until neonatal delivery and confirmation of MAP, may allow successful NA for most women. 43

REFERENCES


DISCLOSURES

Name: John C. Markley, MD, PhD.
Contribution: This author helped design the study, collect the data, analyze the data, and prepare the article.
Name: Michaela K. Farber, MD, MS.
Contribution: This author helped design the study, collect the data, analyze the data, and prepare the article.
Name: Nicola C. Perlman, BA.
Contribution: This author helped design the study, collect the data, analyze the data, and prepare the article.
Name: Daniela A. Carusi, MD, MSc.
Contribution: This author helped design the study, collect the data, analyze the data, and prepare the article.

This manuscript was handled by: Jill M. Mhyre, MD.
38. Frolich MA, Burchfield DJ, Euliano TY, Caton D. A single dose of fentanyl and midazolam prior to cesarean section have no adverse neonatal effects. Can J Anaesth. 2006;53:78–85.