The Ochsner Journal 15:228–236, 2015

Impact of Anesthetic Predictors on Postpartum Hospital Length of Stay and Adverse Events Following Cesarean Delivery: A Retrospective Study in 840 Consecutive Parturients

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Background: Cesarean deliveries are increasing, and associated postoperative adverse events are extending hospitalizations. The aims of the present study were to analyze the role of anesthetic predictors during cesarean delivery on the incidences of extended postpartum hospital length of stay (>4 postoperative days) and adverse events.

Methods: The medical records of 840 consecutive patients who underwent cesarean delivery during a 1-year period were abstracted. Previously reported anesthetic predictors underwent recursive partitioning with 5-fold cross-validation and with LogWorth values ≥2.0 statistically significant at the <0.01 level.

Results: In this study of 840 cesarean delivery patients, 120 parturients (14.3%; confidence interval 12.1%-16.8%) experienced extended postpartum hospital length of stay (>4 hospital days). One anesthetic predictor associated with extended postpartum hospital length of stay was type of anesthetic technique: a 25.6% incidence in parturients receiving general or epidural anesthesia compared to a 9.6% incidence in parturients receiving either spinal or combined spinal-epidural anesthesia (LogWorth value of 7.3). When the amount of intravenous fluids intraoperatively administered to American Society of Anesthesiologists Physical Status III and IV parturients was ≥2,000 mL, the incidence of extended postpartum hospital length of stay decreased from a baseline value of 30.0% to 17.3% (LogWorth value of 2.8). The incidence of adverse events ranged from 0%-5.0%. All regional anesthetic techniques were significantly associated with a decreased incidence of adverse events: 0.7% with spinal anesthesia, 1.9% with epidural anesthesia, and 3.2% with combined spinal-epidural anesthesia when compared to the 51.4% incidence associated with general anesthesia (LogWorth value of 4.0).

Conclusion: These findings suggest that type of anesthetic technique and amount of intraoperative fluids administered during cesarean delivery have important effects on the incidences of extended postpartum hospital length of stay and adverse events following cesarean delivery.

Keywords: *Anesthesia, cesarean section, drug-related side effects and adverse reactions, length of stay*

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INTRODUCTION

The frequency of cesarean delivery is rising worldwide with concomitantly increasing rates of postoperative morbidity, prolonged hospitalization, and associated healthcare costs.[1-4] A 2013 review reported decreases in morbidity and postoperative convalescence following implementation of enhanced recovery protocols in surgical and anesthetic management but also highlighted a need for these protocols to be patient and surgical procedure specific.[5] Although enhanced recovery protocols for cesarean delivery were reported in 2011, they have only been conducted in small-scale studies.[6,7] The aims of the present study were to analyze the association of anesthetic predictors during cesarean delivery on the incidence of extended postpartum length of stay (LOS), defined as >4 postoperative days,[8] and on the incidence of adverse events (AEs).

METHODS

The Institutional Review Board at Ochsner Clinic Foundation approved the study and waived informed consent because the study did not adversely affect the rights and welfare of the patients (Institutional Review Board No. Pro00010563). A consecutive sample of cesarean deliveries was identified by Current Procedural Terminology codes during the study period from November 2012 to November 2013. Eight hundred fifty parturients were initially identified in the time frame of interest, with 10 scheduled cesarean deliveries excluded due to spontaneous vaginal delivery. The medical records of the remaining 840 parturients who underwent cesarean delivery were retrospectively analyzed to review the role of anesthetic predictors on the incidences of extended postpartum LOS and AEs.

Data collected included previously reported *demographic predictors*: maternal age (years), body mass index (BMI, kg/m^2), and American Society of Anesthesiologists Physical Status (ASA PS) score; *antepartum predictors*: gravida, parity, gestational age (weeks), fetal sex, degree of gestational hypertension, gestational diabetes, histories of previous uterine or cervical surgery, placenta previa, or vaginal bleeding during the second half of pregnancy; *intrapartum predictors*: fetal malpresentation at term, suspected intrauterine growth retardation, induced labor, oxytocin augmentation, intrapartum fever ($\geq$37°C), ruptured membranes $>$24 hours, and epidural analgesia;[9] and *anesthetic predictors*: type of anesthetic technique (general, epidural, spinal, combined spinal and epidural [CSE]), type of neuraxial opiate adjuvants (fentanyl and/or morphine), type of vasopressor (phenylephrine and/or ephedrine),[10-14] and the novel anesthetic predictor, amount of intravenous (IV) crystalloid fluids administered during cesarean delivery.

The primary outcome was the measurement of the role of anesthetic predictors on the incidence of extended postpartum LOS.[15] The secondary outcome was the measurement of the role of anesthetic predictors on the incidence of postoperative AEs, as defined by admission to the intensive care unit (ICU) and postoperative incidences of infection (respiratory, abdominal, urinary tract, central venous catheter, wound), respiratory complications (pleural effusion, pneumothorax, pulmonary embolism, unintended intubation, respiratory support $>$1 day, acute respiratory distress syndrome), cardiovascular complications ($>$15 minutes of systemic hypotension, dysrhythmias, acute pulmonary edema, acute myocardial infarction), neurovascular complications (stroke), abdominal complications (diarrhea, acute bowel obstruction, uterine bleed, prolonged paralytic ileus), acute renal dysfunction (increase in creatinine by 0.3 mg/dL), new onset of coagulopathies, and/or hemorrhage requiring blood and blood products.[16]

For neuraxial anesthesia, all parturients were intravenously prehydrated with 500 mL of lactated Ringer's solution. For spinal anesthesia and the spinal component of CSE, bupivacaine 12-14 mg was intrathecally administered via a 27-gauge pencil point needle inserted at the L2-L3 or L3-L4 interspace. Intrathecal administration of 10 mcg of fentanyl and/or 150 mcg of preservative-free morphine sulfate was added to the local anesthetic solution, depending on the preference of the anesthesiologist. For established epidural labor analgesia converted to regional anesthesia for cesarean delivery, either 2% lidocaine or 3% chloroprocaine mixed with fentanyl (1 mcg/kg) was administered in aliquots through the epidural catheter. General anesthesia involved rapid sequence induction using propofol 1-1.5 mg/kg IV and succinylcholine 1 mg/kg IV, followed by maintenance of general anesthesia with $\sim$0.6 minimum alveolar concentration of sevoflurane or desflurane in 50% oxygen blended with either nitrous oxide or air. Fentanyl and morphine IV aliquots were used for supplementation of anesthesia following cross-clamping of the umbilical cord. Cesarean deliveries were routinely carried out through a Pfannenstiel incision. Postoperative analgesia for parturients who had undergone regional anesthesia included oral acetaminophen and oxycodone regimens. For parturients who received general anesthesia, patient-controlled analgesia with IV hydromorphone up to 24 hours with conversion to oral acetaminophen/oxycodone thereafter was prescribed. Discharge from the maternity unit occurred when parturients were free of moderate to severe pain and exhibited adequate oral intake and active participation in infant care.

Statistical Analysis

Categorical variables are presented as counts with percentages and confidence intervals (CI), with differences between the groups assessed using Pearson chi-square (χ^2) tests. P values $<$0.05 were considered statistically significant. Continuous variables with nonskewed distributions are presented as means with standard deviations, with differences between groups assessed using the t test for equal variances. Continuous variables with skewed distributions are presented as medians with 25%-75% interquartile range (IQR), with differences between groups assessed by the Wilcoxon rank sum test. The advanced statistical technique, recursive partitioning with 5-fold cross-validation, was used for its advantage of grouping patients into different levels of risk.[17-25] A calculated LogWorth value of $\geq$2.0 is statistically significant at the $<$0.01 level. Statistical analysis stopped when LogWorth values were $<$2.0.[17,21] Measures of association were calculated utilizing lambda symmetrics to detect relationships between anesthesiologists and the categorical anesthetic predictors, with an overlay plot constructed for the continuous anesthetic predictor, administration of IV fluids during cesarean delivery. Values for lambda range from 0 (no association between predictors and outcomes) to 1 (perfect association). Anesthetic predictors were also examined for the level of interaction by measuring the additive effect of the simultaneous influence of two predictors on outcome.[17] The statistical program JMP (version 9.01, SAS Inc.) was used for statistical analyses.

RESULTS

In this study, 120 of 840 parturients (14.3%; CI 12.1%-16.8%) had extended postpartum LOS. The role of the type of cesarean delivery on the incidence of extended postpartum LOS is shown in Table 1. A progressive and statistically significant increase in the incidence of extended postpartum LOS was observed with increasing surgical urgency. Durations of surgical and anesthesia times were not statistically different between the two groups (Table 2).

The association of demographic, antepartum, intrapartum, and laboratory predictors with extended postpartum LOS is shown in Table 3. Maternal age was not statistically associated with extended postpartum LOS, whereas higher BMI values and higher ASA PS scores were significantly associated with extended postpartum LOS. Decreased

Table 1. Association of Type of Cesarean Delivery on the Incidence of Extended Postpartum Length of Stay (LOS)

Type of Cesarean Delivery, n (%)	Postpartum LOS >4 Days n=120	Postpartum LOS ≤4 Days n=720	*P* Value
Elective, 454 (54)	34 (7.5)	420 (92.5)	<0.0001
Intrapartum, 239 (28)	43 (18.0)	196 (82.0)	
Emergency, 147 (18)	43 (29.3)	104 (70.7)	

gestational age, presence of vaginal bleeding in the second half of pregnancy, preeclampsia and severe preeclampsia, and suspected intrauterine growth retardation were associated with statistically significant higher incidences of extended postpartum LOS, whereas presence of male fetus and previous uterine or cervical surgery had statistically significant lower incidences of extended postpartum LOS. The intrapartum predictors—induced labor, oxytocin administration, ruptured membranes >24 hours, and epidural analgesia—had statistically significant higher incidences of extended postpartum LOS. Preoperative hemoglobin levels were significantly lower in the extended postpartum LOS group (Table 3).

The association of the 31 AEs on the incidence of extended postpartum LOS is shown in Table 4. Frequencies of AEs ranged from 0%-5.0%. The incidences of ICU admission; infection; and respiratory, cardiovascular, and neurovascular complications were significantly higher in the extended postpartum LOS group.

Recursive partitioning with 5-fold cross-validation was performed to determine the role of anesthetic predictors on the incidence of extended postpartum LOS, and the results of that analysis are shown in Figure 1. The incidence of extended postpartum LOS in this study was 14.3% (Figure 1, Node 1). The anesthetic predictor with the greatest statistical significance on the incidence of extended postpartum LOS was type of anesthesia technique with a 9.6% incidence (57/594) observed in parturients who received either spinal or CSE anesthesia (Figure 1, Node 2) vs a 25.6% incidence (63/246) observed in parturients who received either epidural or general anesthesia (Figure 1, Node 3) with an associated LogWorth value of 7.3 (Figure 1, Node 1). The next statistically significant anesthetic predictor on the incidence of extended postpartum LOS was the volume of IV fluids administered during cesarean delivery in parturients who underwent spinal or CSE anesthesia as shown in Nodes 2, 4, and 5 of Figure 1. When the volume of IV fluids administered in this subgroup during cesarean delivery was ≥1,100 mL, a further reduction in the incidence of extended postpartum LOS to 7.3% (37/509 parturients) was observed (Figure 1, Node 4). However, in this subgroup of parturients who received <1,100 mL of IV fluids during anesthetic care, the incidence of extended postpartum LOS increased to 23.5% (20/85 parturients) with an associated LogWorth value of 3.5 (Figure 1, Node 2). No other anesthetic predictor was statistically associated with extended postpartum LOS in this model.

The degree and response to preexisting illness as measured by ASA PS scores with anesthesia predictors on the incidence of extended postpartum LOS was investigated, and the results of this analysis are shown in Figure 2. The incidence of extended postpartum LOS was 14.3% (Figure 2, Node 1). Recursive partitioning grouped ASA PS I and II parturients and ASA PS III and IV parturients (Figure 2, Nodes 2 and 3). ASA PS I and II parturients following cesarean delivery had a 9.9% incidence (65/657) of extended postpartum LOS (Figure 2, Node 2), whereas ASA PS III and IV parturients experienced a 30.0% incidence (55/183) of extended postpartum LOS (Figure 2, Node 3) following cesarean delivery (LogWorth value of 9.1; Figure 2, Node 1). In ASA PS I and II parturients, recursive partitioning found a significant difference in the incidence of extended postpartum LOS by type of anesthetic technique (Figure 2, Nodes 2, 4, and 5). ASA PS I and II parturients who underwent CSE or spinal anesthesia had a 5.9% incidence (28/472) of extended postpartum LOS (Figure 2, Node 4), whereas ASA PS I and II parturients who underwent epidural or general anesthesia had a 20.0% incidence (37/185) of extended postpartum LOS (Figure 2, Node 5) with a calculated LogWorth value of 5.7 (Figure 2, Node 2). Among ASA PS III and IV parturients, a significant difference was observed in the incidence of extended postpartum LOS associated with the amount of IV fluids administered during anesthetic care for cesarean delivery (Figure 2, Nodes 3, 6, and 7). ASA PS III and IV parturients who received ≥2,000 mL of IV fluids during anesthetic care for cesarean delivery experienced a 17.3% incidence (14/81) of extended postpartum LOS (Figure 2, Node 6) when compared to a 40.2% incidence (41/102) (Figure 2, Node 7) in parturients who received <2,000 mL of IV fluids during anesthetic care (LogWorth value of 2.7; Figure 2, Node 3). No other anesthetic predictor was statistically significant in this model.

Recursive partitioning with 5-fold cross-validation was also performed to determine the role of anesthetic predictors on the incidence of AEs, and the results of this analysis are

Table 2. Association of Duration of Operative Care on the Incidence of Extended Postpartum Length of Stay (LOS)

Median Duration of Operative Care, hours:minutes [IQR]	Postpartum LOS >4 Days n=120	Postpartum LOS ≤4 Days n=720	*P* Value
Surgical times	0:54 [0:45-1:03]	0:54 [0:44-1:04]	0.98
Anesthesia times	1:36 [1:25-2:02]	1:36 [1:22-1:52]	0.26

IQR, interquartile range [25%-75%].

Table 3. Association of Demographic, Antepartum, Intrapartum, and Laboratory Predictor on the Incidence of Extended Postpartum Length of Stay (LOS)

Predictor Variable	Postpartum LOS >4 Days n=120	Postpartum LOS ≤4 Days n=720	*P* Value
Demographic			
Maternal age, years, mean (SD)	29.5 (0.5)	29.8 (0.2)	0.5
BMI, kg/m^2, median [IQR]	33.7 [28.6-40.5]	32.8 [28.5-38.2]	0.02
ASA PS,[a] n (%)			
• I	0 (0)	5 (0.7)	<0.0001
• II	65 (54.2)	584 (81.6)	
• III	51 (42.5)	127 (17.7)	
• IV	4 (3.3)	0 (0)	
Antepartum			
Multiparity, n (%)	65 (54.2)	532 (73.9)	0.13
Median gestational age, weeks, [IQR]	34 [30-38]	39 [38-39]	<0.0001
Fetus sex, male, n (%)	62 (51.7)	382 (53.1)	0.01
Previous uterine or cervical surgery, n (%)	35 (29.2)	437 (60.7)	<0.0001
Placenta previa, n (%)	2 (1.7)	13 (1.8)	0.91
Vaginal bleeding in the second half of pregnancy, n (%)	14 (11.7)	17 (2.4)	<0.0001
Degree of gestational hypertension, n (%)			
• Controlled	3 (2.5)	25 (3.5)	0.09
• Preeclampsia	15 (12.5)	17 (2.4)	0.02
• Severe preeclampsia	26 (21.7)	31 (4.3)	0.01
• Eclampsia	1 (0.8)	3 (0.4)	0.98
• HELLP syndrome	1 (0.8)	3 (0.4)	0.98
Gestational diabetes, n (%)	13 (10.8)	76 (10.6)	0.87
Fetal malpresentation at term, n (%)	24 (20.0)	109 (15.1)	0.18
Suspected intrauterine growth retardation, n (%)	16 (13.3)	28 (3.9)	0.0002
Intrapartum			
Induced labor, n (%)	28 (23.3)	61 (8.5)	<0.0001
Oxytocin administration, n (%)	12 (10.0)	30 (4.2)	0.01
Intrapartum fever (≥37°C), n (%)	5 (4.2)	12 (1.7)	0.1
Ruptured membranes >24 hours, n (%)	16 (13.3)	21 (2.9)	<0.0001
Epidural analgesia, n (%)	46 (38.3)	161 (22.4)	0.0003
Laboratory			
Preoperative hemoglobin, gms%, mean (SD)	11.2 (1.5)	11.6 (1.4)	0.03

[a]Values for 4 patients are missing.

ASA PS, American Society of Anesthesiologists Physical Status; BMI, body mass index; gms%, grams of hemoglobin per 100 cc whole blood; HELLP, hemodialysis/elevated liver enzymes/low platelet count; IQR, interquartile range [25%-75%].

shown in Figure 3. The overall incidence of AEs was 3.7% (Figure 3, Node 1) with a statistical difference observed between parturients who received regional vs general anesthesia (Figure 3, Nodes 2 and 3). In parturients who underwent regional anesthesia, an overall AE incidence of 1.6% (13 AEs in 805 parturients) was observed (Figure 3, Node 2). Further analysis in this subgroup revealed 3 AEs were observed in 408 (0.7%) parturients who received spinal anesthesia, 4 AEs were observed in 211 (1.9%) parturients who received epidural anesthesia, and 6 AEs were observed in 186 (3.2%) parturients who received CSE anesthesia (Figure 3, Node 2), compared to 18 AEs observed in 35 (51.4%) parturients who received general anesthesia (LogWorth value of 4.0; Figure 3, Node 1). No other anesthetic predictor was significantly associated with AEs in this model.

As shown in Figure 4, the amount of IV fluids administered during anesthetic care for cesarean delivery was inversely associated with the incidence of extended postpartum LOS.

When parturients were combined into two ASA PS score groups, I and II vs III and IV, to allow robust statistical analysis, ASA PS scores had a significant role in the type of cesarean delivery (χ^2=19.6, P<0.0001). The type of cesarean delivery had a statistically significant association with the type of anesthetic technique, with intrapartum and

Table 4. Association of Adverse Events on the Incidence of Extended Postpartum Length of Stay (LOS)

Adverse Event, n (%)	Postpartum LOS >4 Days n=120	Postpartum LOS ≤4 Days n=720	*P* Value
Intensive care unit admission	3 (2.5)	1 (0.1)	0.006
Infection	2 (1.7)	7 (1.0)	0.019
Respiratory complications	4 (3.3)	3 (0.4)	0.017
Cardiovascular complications	6 (5.0)	1 (0.1)	<0.0001
Neurovascular complications	2 (1.7)	0 (0)	0.005
Abdominal complications	0 (0)	0 (0)	NA
Acute renal dysfunction	1 (0.8)	1 (0.1)	0.230
Coagulopathies	0 (0)	0 (0)	NA

NA, not applicable.

emergency cesarean deliveries having higher incidences of epidural and general anesthetics (Table 5).

When the amount of IV fluids during anesthesia care was categorized by type of cesarean anesthetic technique, parturients who underwent spinal and CSE anesthetics received median [IQR] IV volumes of 2.0 L [1.5-2.5] for spinal anesthesia and 2.0 L [1.6-2.5] for CSE anesthesia. In contrast, parturients who underwent general and epidural anesthetics received significantly less median [IQR] volumes of 1.8 L [1.4-2.0] and 1.7 L [1.0-2.2], respectively, (χ^2=24.5, degrees of freedom [DF]=3, $P<0.0001$) during anesthetic care.

Slight statistically significant measures of association were observed between anesthesia staff and type of anesthetic technique: lambda symmetric 0.03, standard error (SE) 0.01, CI 0.01-0.05; type of neuraxial opiates: lambda symmetric 0.09, SE 0.01, CI 0.07-0.11; and type of vasopressor: lambda symmetric 0.01, SE 0.003, CI 0.0006-0.01. No pattern was observed in the overlay plot between the amount of IV fluids administered during anesthesia care and the staff anesthesiologists, and no statistical significance was observed following statistical analysis (χ^2=56.9, DF=42, P=0.06). Interaction profiles for the categorical anesthetic predictors showed mild interaction between IV fluids administered during cesarean delivery and type of vasopressors used (data not shown).

DISCUSSION

With the increasing rates of cesarean delivery,[1-4] healthcare organizations will need to address the predictors that can be modified by healthcare teams to reduce the incidences of extended postpartum LOS and AEs. In this retrospective study of 840 parturients who underwent cesarean delivery, a 14.3% incidence of extended postpartum LOS with 31 AEs was observed. Regarding demographic predictors, bivariate analysis revealed that maternal age was not statistically associated with extended postpartum LOS, whereas BMI and ASA PS scores were statistically associated with extended postpartum LOS. Our observation that maternal age was not associated with

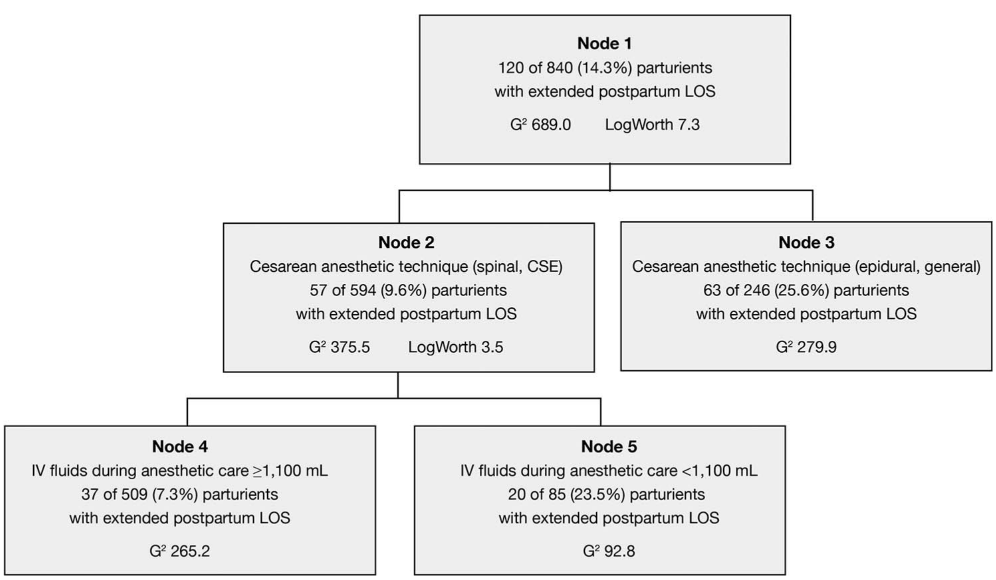

Figure 1. Recursive partitioning graph of the role of anesthetic predictors on extended postpartum length of stay (LOS). CSE, combined spinal epidural; G^2, G-square statistic; IV, intravenous. LogWorth values ≥2.0 are statistically significant at the <0.01 value. RSquare=0.0679 for 5-fold cross-validation calculation. RSquare=0.0739 for the overall calculation.

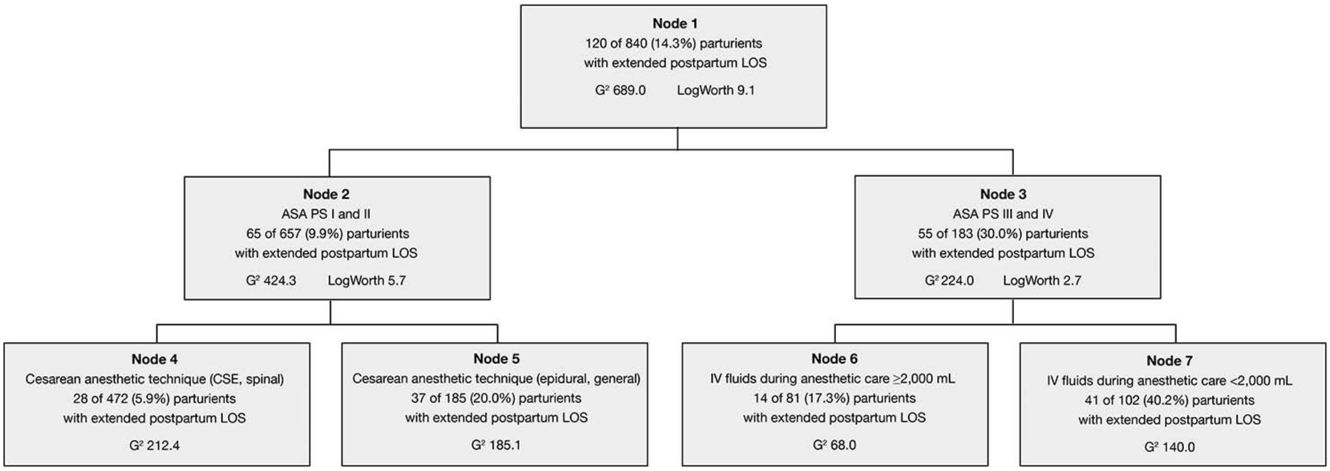

Figure 2. Recursive partitioning graph of the role of preexisting medical illness as measured by the American Society of Anesthesiologists Physical Status (ASA PS) scores with anesthetic predictors on the incidence of extended postpartum length of stay (LOS). CSE, combined spinal epidural; G^2, G-square statistic; IV, intravenous. LogWorth values $\geq$2.0 are statistically significant at the $<$0.01 value. RSquare=0.535 for 5-fold cross-validation calculation. RSquare=0.0599 for the overall calculation. Values for 4 patients are missing.

extended postpartum LOS is in contrast to Liu et al who observed an association of maternal age to extended postpartum LOS.[15] The difference may be because of differences in the sample size and design of the studies. However, our observation that BMI increases the incidence of postpartum LOS is in agreement with other studies.[26,27] The antepartum predictors of decreased gestational age, vaginal bleeding in the second half of pregnancy, preeclampsia and severe preeclampsia, and suspected intrauterine growth retardation had statistically significant higher incidences of extended postpartum LOS, whereas previous uterine or cervical surgery had a statistically significant lower incidence of extended postpartum LOS. The intrapartum predictors of induced labor, oxytocin administration, ruptured membranes $>$24 hours, and epidural analgesia had statistically significant higher incidences of extended postpartum LOS. Preoperative hemoglobin levels had lower, statistically significant values in the extended postpartum LOS group. These observations are comparable to other studies in assessment of antepartum and intrapartum risk factors for cesarean delivery.[10,11,14]

Statistical associations of extended postpartum LOS were observed with type of cesarean delivery. No statistical associations were observed between duration of surgical or anesthetic care times on the incidence of extended postpartum LOS. These findings suggest that increasing surgical acuity results in shorter preoperative preparation times, including IV hydration.

Recursive partitioning identified that the anesthetic predictor with the greatest statistical significance was the type

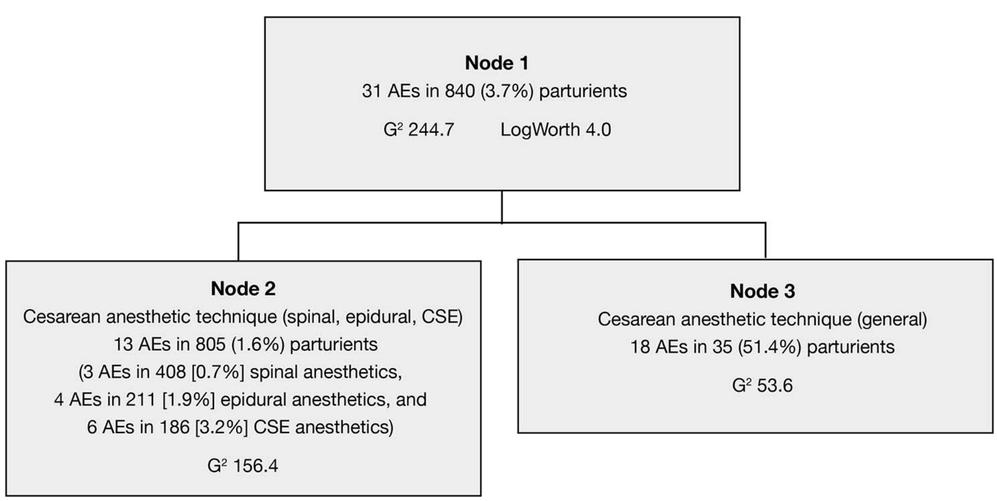

Figure 3. Recursive partitioning graph of the role of anesthetic predictors on adverse events (AEs). G^2, G-square statistic; CSE, combined spinal-epidural. LogWorth values $\geq$2.0 are statistically significant at the $<$0.01 value. RSquare=–0.381 for 5-fold cross-validation calculation. RSquare=0.1417 for the overall calculation.

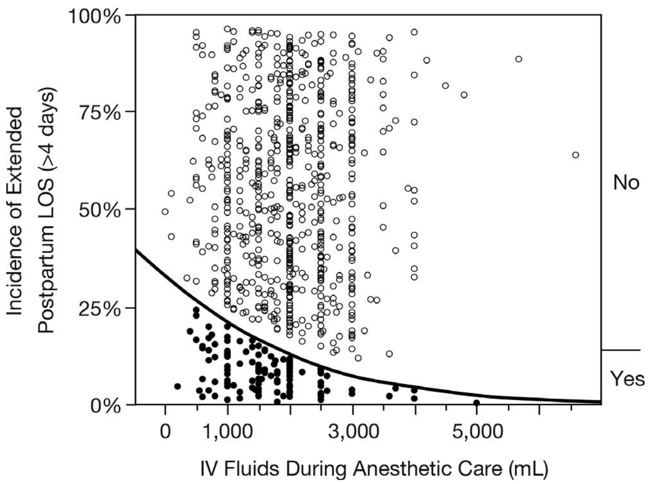

Figure 4. Logistic fit graph of the association of intravenous (IV) fluids administered during anesthetic care with the incidence of extended postpartum length of stay (LOS) (n=829, χ^2=20.9, $P<0.0001$). χ^2, chi-square statistic. Yes (closed circles)=>4 days. No (open circles)=≤4 days.

of anesthetic technique with a 9.6% incidence of extended postpartum LOS observed in the spinal/CSE group and a 25.6% incidence observed in the epidural/general anesthetic group. These observations are in agreement with a previous study that reported neuraxial anesthesia is associated with shorter postpartum LOS when compared to general anesthesia following cesarean delivery[28] but differ in that epidural anesthesia in our study did not confer the same benefit. The differences observed in our study and the 2009 study by Fassoulaki et al[28] may be because the latter study investigated only women with uncomplicated pregnancies scheduled for elective cesarean delivery during a 3-year period, whereas our study examined 840 consecutive parturients during a 1-year period.

The next statistically significant anesthetic predictor identified in this analysis was IV fluids administered during anesthetic care within the spinal/CSE anesthetic group. In this group, when IV fluids ≥1,100 mL were administered, a further reduction in the incidence of extended postpartum LOS to 7.3% was observed. However, when parturients of this anesthetic group received <1,100 mL of IV fluids during anesthetic care, the extended postpartum LOS incidence of 23.5% approached the 25.6% extended postpartum LOS incidence observed in the epidural/general anesthetic group. Logistic fit analysis also demonstrated that the amount of IV fluids administered during cesarean delivery was significantly associated with the incidence of extended postpartum LOS. Parturients who underwent spinal or CSE anesthesia received higher IV fluid volumes when compared to parturients who underwent general and epidural anesthesia during cesarean delivery. This finding suggests that the amount of IV fluids administered during anesthetic care for cesarean delivery has a role on the incidences of extended postpartum LOS and AEs. The observation that surgical and anesthesia care times were similar in the two groups supports the concept that the volume of IV fluids administered during these procedures plays a major role on the incidences of extended postpartum LOS and AEs. Two clinical reviews published in 2012 addressed IV fluid administration during cesarean delivery in the treatment of hypotension,[29,30] but to our knowledge, the relationship between IV fluid management during cesarean delivery on the incidence of postpartum LOS has not been reported. Although the degree and response to systemic illness, as measured by ASA PS scores, had a significant effect on the incidence of extended postpartum LOS, administration of IV fluids ≥2,000 mL during cesarean delivery to ASA PS III and IV parturients was associated with a decreased incidence of extended postpartum LOS (from 30.0% to 17.3%), whereas ASA PS III and IV parturients who received <2,000 mL had an increased incidence (from 30.0% to 40.2%). These results suggest that appropriate hydration is required during anesthetic care for cesarean delivery, especially in ASA PS III and IV parturients. Overall, these findings suggest that the type of anesthetic technique and the amount of IV fluids administered during anesthetic care for cesarean delivery play major clinical roles on the incidence of extended postpartum LOS.

Recursive partitioning was also used to determine the role of anesthetic predictors on the incidence of AEs, with greater numbers of AEs observed in the general anesthesia group. This observation, along with the discovery that the general anesthesia group received lesser amounts of IV fluids during anesthetic care, supports the hypothesis of occult hypoperfusion and resultant end-organ injury, expressed as AEs.[31,32]

A limitation of retrospective studies is incomplete data records that require imputation strategies for missing data to utilize those records.[18] However, electronic medical records allow near 100% data collection as observed in this study (0.3% missing data). A limitation of this study was the statistically significant measures of association observed between type of anesthetic technique, neuraxial opiates, and vasopressors used by anesthesia staff during cesarean delivery. Interaction profiles noted a mild interaction between IV fluids administered during cesarean delivery and type of vasopressors used. No difference was

Table 5. Association of Type of Cesarean Delivery by Type of Anesthetic Technique

	Type of Anesthetic Technique				
Type of Cesarean Delivery, n (%)	Spinal	CSE	Epidural	General	*P* Value
Elective, 454 (54)	295 (65.0)	142 (31.3)	13 (2.9)	4 (0.9)	<0.0001
Intrapartum, 239 (28)	77 (32.2)	23 (9.6)	133 (55.7)	6 (2.5)	
Emergency, 147 (18)	36 (24.5)	21 (14.3)	65 (44.2)	25 (17.0)	

CSE, combined spinal epidural.

observed in the amounts of IV fluids administered during cesarean delivery by anesthesiologists. The personal preference in the type of anesthetic technique used by anesthesiologists had a small, but practically insignificant (3%), contribution to the incidence of extended postpartum LOS.

Strengths of the study include data that represent a consecutive set of parturients who experienced a common outcome. In addition, recursive partitioning was used in statistical analysis. This robust statistical technique is easy to understand with predictions in percentages interpreted from flow diagrams rather than from statistical tables containing beta coefficients, standard errors, and odds ratios derived from multivariable analyses.[18,19] Additionally, recursive partitioning allows easy clinical interpretation of the results and does not require extensive knowledge about statistical mathematics.[21-24] With increasing interest in minimizing LOS and AEs for hospitalized patients following surgical care,[24] recursive partitioning is a valuable statistical tool that can help clinicians identify subgroups of patients who are at risk and direct appropriate healthcare resources to these subgroups,[25] an area difficult to explore with multivariable analysis.[18,19] Another strength of this model was the use of 5-fold cross-validation to obtain a robust statistical model.[22]

CONCLUSION

In summary, the incidence of extended postpartum LOS in a parturient population undergoing cesarean delivery was 14.3% (CI 12.1%-16.8%). Recursive partitioning identified that the type of anesthetic technique and the amount of IV fluids administered during anesthetic care were significantly associated with the incidence of extended postpartum LOS and with the incidence of AEs. Finally, the analysis supports a liberal fluid strategy in cesarean delivery regardless of the anesthetic technique selected.

ACKNOWLEDGMENTS

The authors have no financial or proprietary interest in the subject matter of this article.

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