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Obstetric interventions and maternal morbidity among women who experience severe postpartum hemorrhage during cesarean delivery

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Abstract

Background—Compared to vaginal delivery, women undergoing cesarean delivery are at increased risk of postpartum hemorrhage. Management approaches may differ between those undergoing prelabor cesarean delivery compared to intrapartum cesarean delivery. We examined surgical interventions, blood component use, and maternal outcomes among those experiencing severe postpartum hemorrhage within the two distinct cesarean delivery cohorts.

Methods—We performed secondary analyses of data from two cohorts who underwent prelabor cesarean delivery or intrapartum cesarean delivery at a tertiary obstetric center in the United States between 2002 and 2012. Severe postpartum hemorrhage was classified as an estimated blood loss 1500 mL or receipt of a red blood cell transfusion up to 48 h post-cesarean delivery. We examined blood component use, medical and surgical interventions and maternal outcomes.

Results—The prelabor cohort comprised 269 women and the intrapartum cohort comprised 278 women. In the prelabor cohort, one third of women received red blood cells intraoperatively or postoperatively, respectively. In the intrapartum cohort, 18% women received red blood cells

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Source of work: Secondary analysis of data sourced from a population that underwent cesarean delivery at Lucile Packard Children's Hospital (LPCH), a tertiary US obstetric center, between January 2002 and December 2012.

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intraoperatively vs. 44% postoperatively ($P<0.001$). In the prelabor and intrapartum cohorts, methylergonovine was the most common second-line uterotonic (33% and 43%, respectively). Women undergoing prelabor cesarean delivery had the highest rates of morbidity, with 18% women requiring hysterectomy and 16% requiring intensive care admission.

Conclusion—Our findings provide a snapshot of contemporary transfusion and surgical practices for severe postpartum hemorrhage management during cesarean delivery. To determine optimal transfusion and management practices in this setting, large pragmatic studies are needed.

Keywords

Cesarean Section; Postpartum Hemorrhage; Maternal Morbidity

Introduction

In the United States, postpartum hemorrhage (PPH) is a leading cause of severe maternal morbidity and mortality.^{1–3} In particular, women undergoing cesarean delivery (CD) are at greater risk for severe PPH compared to women undergoing vaginal delivery, and women undergoing CD after labor are at highest risk. Based on data from Norwegian population-wide studies, the risk of PPH is higher for women undergoing intrapartum CD compared with prelabor CD (3.1% vs. 2%, respectively).^{4, 6} Intrapartum factors such as chorioamnionitis, prolonged labor and oxytocin exposure^{7–11} may explain why the risk of atonic PPH is higher among those undergoing intrapartum CD population compared to those undergoing prelabor CD. Less well described are PPH management practices for women experiencing severe PPH during prelabor or intrapartum CD.

Examining contemporary practices for managing severe PPH during CD has important clinical value. Firstly, there is a lack of consensus about best practice. In recent reviews of national obstetric societies' PPH guidelines,^{12,13} recommendations for medical, surgical, and transfusion management were inconsistent. Secondly, in the CD setting, few studies have reported on the types and utilization rates of medical and surgical interventions and blood component therapies for PPH management.^{14–16} Thirdly, in the United States the rate of PPH has increased by 42% between 1994 and 2006,¹⁷ therefore analyzing current PPH management practices can inform clinical practice and the design for future pragmatic studies comparing different therapeutic interventions.

The planning and management of PPH may vary according to whether PPH occurs during prelabor CD or intrapartum CD. In preparation for major blood loss during prelabor CD, clinicians typically ensure that blood products, resources and experienced staff are available on the day of surgery. Such planning and coordination are less likely if severe unanticipated PPH occurs during intrapartum CD. Therefore, the approach to PPH management may differ for those undergoing prelabor CD compared to intrapartum CD. However, there has been little study of the rates of blood product utilization, medical and surgical intervention and maternal morbidity after severe PPH in the prelabor CD and intrapartum CD populations.

We retrospectively reviewed rates of blood product utilization as our primary outcome of interest in two CD subpopulations (prelabor CD and intrapartum CD) that experienced

severe PPH at a tertiary US obstetric center. Secondary outcomes included medical/surgical interventions and hemorrhage-related maternal morbidity.

Methods

Descriptive analyses of two separate CD cohorts (prelabor CD and intrapartum CD) were performed. The cohorts were sourced from prior case-control studies examining risk factors for PPH during prelabor CD and intrapartum CD.¹⁸ The study was approved by the Stanford University IRB (Protocol ID=25236).

Details of the study cohorts are summarized. The study cohorts were identified from a population that underwent CD at Lucile Packard Children's Hospital (LPCH), a tertiary US obstetric center, between January 2002 and December 2012. Between 2002 and 2006, paper (written) medical records were used at LPCH. Women who underwent CD were identified using International Classification of Diseases (ICD-9) procedure codes (74.x) and Current Procedural Terminology (CPT) codes (01961, 01963, 01968, 59510, 59515, 59618, 59620, 59622, 1008991, 1014218, and 1014220).

Women who experienced severe PPH between 2002 and 2006 were initially identified by searching for an accompanying ICD-9 code for PPH (666.x). In 2007, LPCH transitioned to an electronic medical record system. The computerized clinical database (LPCH Information and Knowledge System) was queried. Medicare Severity Diagnosis Related Group codes for CD (765 and 766) were used to identify women who underwent CD between January 2007 and December 2012. This database also contained data on estimated blood loss (EBL) data and transfusion (if available). In total, there were 6997 CDs between 2002–2006, and 8192 CDs between 2007–2012; of these, 547 (3.6%) women had severe PPH after CD.

Medical charts were reviewed by two trained research assistants (PH, BR). Women were confirmed as cases if the documented EBL in the operative report was ≥1500 mL or if a red blood cell (RBC) transfusion was administered during CD or within 48 h after CD. These criteria are in line with those described in the literature.^{5, 6, 19, 20} Clinical and transfusion data were abstracted from the patients' medical records.

Criteria were established *a priori* to differentiate women who underwent prelabor CD or intrapartum CD. Prelabor CD inclusion criteria included scheduled CD without labor, CD following unsuccessful external cephalic version, and CD for obstetric or fetal indications without labor or induction. Intrapartum CD inclusion criteria included women with documented painful and regular contractions or induction of labor prior to CD. Women with known hematologic or coagulation disorders, and those receiving anticoagulation prior to surgery were excluded from analysis.

For each record we abstracted data on maternal demographics, obstetric characteristics, medical interventions for hemorrhage (including second-line uterotonics such as methylergonovine maleate, misoprostol, carboprost tromethamine), uterine balloon tamponade (Bakri balloon), interventional radiology, surgical interventions for hemorrhage (including vessel ligation and hysterectomy), and intraoperative and postoperative blood product utilization. For women undergoing prelabor CD, those with abnormal placentation

(based on the obstetrician's operative note or from the placental pathology report, if available) were identified. Data for patients with a past history of uterine surgery (myomectomy, dilatation and evacuation or curettage) were only abstracted for the prelabor CD cohort.

For each patient, postpartum laboratory indices (up to 48 h post-CD) were reviewed; data for nadir plasma hemoglobin, platelet, plasma fibrinogen indices and the most extreme (highest) international normalized ratio (INR) and activated partial thromboplastin times (APTT) were collected. The location to which patients were sent postpartum (post-partum ward, monitored bed, or intensive care unit (ICU)), and their postpartum morbidities (respiratory failure, pulmonary edema, acute respiratory distress syndrome (ARDS), renal failure, maternal death) were recorded. Of note, LPCH does not have an obstetric high-dependency unit or a 'step-down' unit.

Statistical Analysis

Data are presented as n (%), mean (SD), and median [IQR]. Between group comparisons were analyzed using Wilcoxon matched pairs signed-rank test for continuous data, and Chi-squared test or Fisher's exact test for categorical data. Statistical analyses were performed using STATA version 12 (College Station, TX); $P < 0.05$ was considered statistically significant.

Results

Prelabor Cesarean Delivery

We identified 269 women with severe PPH undergoing CD. Maternal and perioperative characteristics are presented in Table 1. The median EBL was 1600 [1500–2000] mL, and 223 (83%) women had at least 1500 mL EBL. RBC transfusion was used intraoperatively or within 48 h post-CD in 148 (55%) women. Intraoperative and postoperative transfusion data are presented in Table 2 for all cases and for women stratified by presence or absence of abnormal placentation. During the intraoperative and postoperative periods, the rate of RBC transfusion was substantially higher than the transfusion rates of plasma, platelet, and cryoprecipitate. For the 49 cases with abnormal placentation, blood components were more likely to be used in the intraoperative period compared to the postoperative period, whereas for 220 cases without abnormal placentation the rates of blood component use in the two periods were not significantly different (Table 2).

Data on pharmacological treatment, medical and surgical interventions and laboratory indices are presented in Table 3. Rates of second line uterotonic use in women experiencing severe PPH were: methylergonovine 33.1%, carboprost 21.6%, and misoprostol 19.3%. The most frequent morbidities were hysterectomy (18%) and the need for ICU admission (16%). In 47 women who required hysterectomy, 34 (72%) had abnormal placentation. In 43 women who required ICU admission, 21 (49%) had abnormal placentation.

Laboratory indices in women with and without abnormal placentation were also examined. In women with abnormal placentation, the nadir hemoglobin (Hb) concentration was 8.8 (1.6) g/dL, platelet count 142 (52) $\times 10^9$ /L, fibrinogen 289 (129) mg/dL, and the most

extreme INR was 1.3 [1.1 – 1.4] and APTT 33.2 [29.8 – 40.3] s. In women without abnormal placentation, the nadir Hb was 8.1 (1.5) g/dL, platelet count 150 (55) $\times 10^9/L$, fibrinogen 283 (126) mg/dL, and the most extreme INR was 1.2 [1.1 – 1.4] and APTT 33.1 [29.5 – 38.2] s.

Data on postpartum disposition and ICU-related morbidities are presented in Table 3. The majority (82%) of women were transferred to the ward. For those admitted to the ICU, 8% women required mechanical ventilation for respiratory failure.

Intrapartum Cesarean Delivery

We identified 278 women with severe PPH undergoing intrapartum CD. Maternal and perioperative characteristics are presented in Table 4. The mean EBL value among women with severe PPH was 1685 (665) mL; 209 (75.4%) women had an EBL greater than 1500 mL. RBC transfusion was given intraoperatively or within 48 h post-CD to 157 (56.5%) women. Intraoperative and postoperative blood product data are presented in Table 5. Rates of intraoperative and postoperative RBC transfusion were substantially higher than rates of plasma, platelet, and cryoprecipitate transfusion. A lower proportion of women received RBCs during the intraoperative period compared to the postoperative period (18.3% vs. 43.9%, respectively; $P < 0.001$). In contrast, rates of plasma and platelet transfusion did not significantly differ between the intraoperative and postoperative periods. In women who received RBC, plasma, platelets and cryoprecipitate, the median number of units of each blood product transfused did not significantly differ between the two periods.

Data on pharmacological treatment, medical and surgical interventions, and laboratory indices are presented in Table 6. Rates of second line uterotonic use were relatively high; 43% received methylergonovine maleate, 28.1% received carboprost, and 22.7% received misoprostol. Other interventions included a B-lynch suture (6.8%), uterine balloon tamponade (3.6%), and vessel ligation (2.9%).

The overall rate of ICU admission was 10%. For those admitted to the ICU, 6% women required mechanical ventilation for respiratory failure.

Discussion

The findings provide a snapshot of transfusion and surgical practices for management of severe PPH during prelabor and intrapartum CD in a tertiary referral center. Women in each CD cohort commonly received RBC transfusion. For those who underwent prelabor CD with severe PPH, abnormal placentation accounted for 72% of cesarean hysterectomies and 49% of ICU admissions.

Studies examining transfusion use in obstetrics have predominantly focused on indicators and risk factors for transfusion.^{21–25} Data on the volumes and types of blood components used to treat obstetric hemorrhage are more limited. Examining the type and volume of blood component usage in relation to delivery mode may highlight transfusion practices and the effectiveness of transfusion decision-making in obstetrics. In this study, RBCs were the most common blood component transfused in both CD cohorts, a finding consistent with

those of Patterson et al. who reported that 86% of transfusions given before or after delivery comprise RBCs.²¹ In the intrapartum CD cohort, it is unclear why the rate of RBC transfusion was substantially higher postpartum compared to intrapartum (44% vs. 18%). Because visual assessment of bleeding may underestimate the overall volume of blood loss,^{26, 27} it is possible that severe anemia was only detected after surgery, which may explain why the rate of RBC transfusion was higher post-CD in this cohort. In both CD cohorts, there was moderate variability in the number of units of RBC transfused intraoperatively and postoperatively. In a study of women transfused after delivery, wide ranges in the number of units of RBC, FFP, cryoprecipitate, and platelets transfused per patient (1–20, 1–20, 1–2, and 1–3, respectively) were reported.¹⁵ Future studies should account for patient-level, provider-level and hospital-level factors that influence the timing of transfusion and the number of blood components used during the peri-delivery and postpartum periods.

In women undergoing prelabor CD, rates of plasma, platelet, and cryoprecipitate transfusion were higher during the intrapartum period compared to the postpartum period; in the intrapartum CD cohort, the rates were similar in both time periods. The reasons for these differences are unclear, but a possible explanation is that the timing and treatment of coagulopathy occurs more promptly after PPH onset for women experiencing ‘anticipated’ PPH during prelabor CD compared with those who experience ‘unanticipated PPH’ during intrapartum CD. The incidence and severity of coagulopathy may differ according to the etiology of ‘anticipated PPH’, such as abnormal placentation, and ‘unanticipated PPH’, such as uterine atony. Our findings are similar to previously reported studies; Green et al. examined laboratory indices and blood product utilization for 181 women who received 8 units RBC within 24 h of delivery.¹⁴ The median time from bleeding onset to transfusion of the first RBC unit was significantly shorter for women delivered during weekdays by elective CD (15 min) compared to those who delivered by vaginal delivery or non-elective CD (median time range 43–56 min).

In each study cohort, methylergonovine was the most commonly used second line uterotonic. Similar findings have been reported in population-wide studies. In a prior study of 2.1 million women hospitalized for delivery, methylergonovine was the most commonly used second-line uterotonic.²⁸ Methylergonovine has also been associated with a lower risk of hemorrhage-related morbidity compared to carboprost.²⁹ Rates of major surgical intervention for control of hemorrhage were low, which suggests that early recognition and medical interventions, such as second-line uterotonics, are probably effective. This finding should not de-emphasize the importance of surgical interventions if bleeding fails to respond to pharmacological therapy, particularly since PPH may occur from non-atonic causes, such as genital tract lacerations, vascular or visceral injury.

In the prelabor CD cohort, abnormal placentation accounted for at least 50% of hysterectomies and ICU admissions, and blood component usage was high. These findings are consistent with other studies,^{25, 30, 31} and provide further evidence of the association of hemorrhage-related morbidity with abnormal placentation.

In both CD cohorts, the median values for the most extreme Hb, fibrinogen, platelet and INR indices were not markedly deranged. Green et al. reported that among women receiving major transfusion, the most extreme PT and APTT values did not reach a commonly recognized plasma trigger ($>1.5 \times$ mean normal).¹⁴ However, Green et al.¹⁴ also reported that women experienced a higher median EBL (6 L) and had lower nadir platelet counts (ranging from 54 to $83 \times 10^9/L$) and fibrinogen levels (ranging from 60 to 190 mg/dL) compared to those observed in our prelabor and intrapartum CD cohorts. It is possible that the coagulation indices were not markedly deranged in our study because median EBL values in both cohorts were not as severe. The timely use of plasma, cryoprecipitate, and platelets may have also attenuated any marked derangement in INR, APTT, fibrinogen or platelet levels. More importantly, the lack of high-quality evidence to confirm the reliability of PT, INR, and APTT tests for assessing coagulopathy or guiding bleeding management limits our ability to make worthwhile inferences from these data.³² In contrast, during early PPH, a plasma fibrinogen level < 200 mg/dl has been shown to be a strong predictor for progression into severe PPH.^{33, 34}

Rates of severe obstetric morbidity were low. A possible explanation is that blood loss volumes and blood component usage were not excessively high. In contrast, the ICU admission rate in both cohorts was $>10\%$, which may be explained by the lack of an obstetric high-dependency unit at our institution. Other studies have confirmed that hemorrhage is a leading indicator of obstetric ICU admission.^{3,35,36} In both cohorts, the most common ICU morbidities were the need for mechanical ventilation and pulmonary edema. Future studies are needed to identify the most likely indications for mechanical ventilation and etiologies for pulmonary edema, such as respiratory failure secondary to transfusion associated circulatory overload.

A strength of this study was that detailed clinical, transfusion, and laboratory data about women with severe PPH were obtained, but there were limitations. Data were sourced from a tertiary US obstetric center that provides 24 hour in-house anesthesia and obstetric attending coverage, therefore the generalizability of our findings to non-academic centers without in-house coverage is uncertain. Based on manual chart review, it was not possible to determine the method of blood loss measurement (visual estimation, gravimetric or volumetric measurement). Since EBL may have been underestimated for some patients with severe blood loss, RBC transfusion within 48 h of CD was included in our criteria for severe PPH. We could not assess patient-level factors that may influence the decision to transfuse, such as a physician's response to altered maternal hemodynamic indices. Future studies that prospectively examine the timing and extent of transfusion during and after the acute period of blood loss are needed.

We did not determine the success rates for each invasive and surgical technique. Although the success rates of intrauterine balloon tamponade, embolization, and uterine compression sutures are high (92%, 91%, and 92%, respectively),³⁷ there are no comparative studies and the choice of intervention is likely to vary according to etiology, provider experience and preference, and equipment availability.¹⁶

During the study period, our institution did not have a specific protocol-driven approach for transfusion in obstetrics, such as ‘fixed ratios’ of RBC:plasma:platelets, and transfusion was at the discretion of the attending obstetrician and/or anesthesiologist. However, our institution has recently developed a targeted approach to pre-transfusion testing and implemented a massive transfusion protocol specific to obstetrics. In addition, over the last two years, we have been using point-of-care testing (Thromboelastography®; Haemonetics Corp. Braintree, MA) to assist with PPH management. Details of these approaches have been recently described.^{38,39}

In conclusion, the rates of RBC transfusion were relatively high in women who have severe PPH during prelabor CD or intrapartum CD. Hysterectomy and ICU admission were common in women who underwent prelabor CD for abnormal placentation. Population-wide studies are needed to determine the extent to which maternal outcomes are influenced by different transfusion and surgical practices. Large pragmatic studies may be beneficial for comparing the effects of different PPH interventions on maternal outcomes.

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- Outcomes after severe hemorrhage during cesarean section were examined.
- Methylergonovine is the most common second line uterotonic.
- One third of women receive red blood cell transfusions.
- Hysterectomy is a key intervention for severe hemorrhage during prelabor cesarean section.

Table 1

Characteristics of Women with Severe Postpartum Hemorrhage undergoing Prelabor Cesarean Delivery.

	Severe PPH (n=269)
Maternal age (y)	34 (6)
Weight at delivery (kg) ^a	84 (22)
Insurance	
Private	176 (65.4%)
Government-assisted/Other	93 (34.6%)
Race/Ethnicity	
Non-Hispanic White	77 (28.6%)
Hispanic	82 (30.5%)
Non-Hispanic Black	14 (5.2%)
Asian	76 (28.3%)
Other	20 (7.4%)
Chronic hypertension	23 (8.6%)
Gestational age at delivery (weeks)	37 [34 – 38]
Parity	1 [0–2]
Number of prior CDs	
0	139 (51.7%)
1	68 (25.3%)
2	42 (15.6%)
3	20 (7.4%)
Type of pregnancy	
Singleton	210 (78.1%)
Multiple pregnancy	59 (21.9%)
Placenta previa	92 (34.2%)
GDM	59 (21.9%)
Pre-eclampsia	37 (13.7%)
Prior history of D&C or D&E	66 (24.5%)
Prior history of myomectomy	13 (4.8%)
Predelivery Hb (g/dl) ^b	11.6 (1.4)
Time of delivery	
Weekday daytime	195 (72.5%)
Weekday nighttime	32 (11.9%)
Weekend	42 (15.6%)
Mode of anesthesia	
Spinal	103 (38.3%)
CSE	117 (43.5%)
Epidural	19 (7.1%)

	Severe PPH (n=269)
General anesthesia	30 (11.1%)
Type of uterine incision	
Low transverse	211 (78.4%)
Other	58 (21.6%)

Data presented as n (%), mean (SD), median [IQR]

CD = cesarean delivery; CSE = combined spinal-epidural; D&C = dilatation and curettage; D&E = dilatation and evacuation; GDM = gestational diabetes; Hb = hemoglobin

^aData available for 268 patients

^bData available for 262 patients

Table 2

Transfusion Data for Patients with Severe Postpartum Hemorrhage undergoing Prelabor Cesarean Delivery

	Intraoperative Transfusion	Transfusion in first 48 h postpartum	P-value
All women (n=269)			
Red Blood Cells	91 (33.8%)	90 (33.5%)	0.94
Number of units transfused ^a	3 [2 – 3]	2 [2 – 5]	0.05
Plasma	36 (17.1%)	21 (7.8%)	0.001
Number of units transfused ^b	4 [2 – 6]	2 [2 – 4.5]	0.67
Platelets	26 (9.7%)	10 (3.7%)	0.005
Number of units transfused ^{c*}	2 [1 – 4]	1 [1 – 2]	-
Cryoprecipitate	9 (3.3%)	9 (3.3%)	1.0
Number of pools transfused ^{d*}	1 [1 – 2]	4 [2 – 6]	-
Women without abnormal placentation (n=220)	N=220		
Red Blood Cells	58 (26.4%)	74 (33.6%)	0.1
Number of units transfused ^a	3 [2 – 6]	2 [2 – 3]	0.35
Plasma	25 (11.4%)	19 (8.6%)	0.33
Number of units transfused ^b	2 [2 – 6]	2 [2 – 5]	0.67
Platelets	12 (5.5%)	9 (4.1%)	0.49
Number of units transfused ^{c*}	2 [1 – 4]	1 [1 – 2]	-
Cryoprecipitate	5 (2.3%)	8 (3.6%)	0.42
Number of pools transfused ^{d*}	1 [1 – 2]	3 [1.5 – 8]	-
Women with abnormal placentation (n=49)			
Red Blood Cells	33 (67.4%)	16 (32.7%)	<0.001
Number of units transfused ^a	6 [3 – 8]	2 [2 – 2]	0.06
Plasma	21 (42.8%)	2 (4.1%)	<0.001
Number of units transfused ^b	4 [2 – 6]	8 [3 – 13]	0.001
Platelets	14 (28.6%)	1 (2%)	<0.001
Number of units transfused ^{c*}	2 [1 – 4]	2	-
Cryoprecipitate	4 (8.2%)	1 (2%)	0.16
Number of pools transfused ^{d*}	1 [1 – 1.5]	4	-

Data presented as n (%), median [IQR]

^a only women who received red blood cells were analyzed^b only women who received plasma were analyzed^c only women who received platelets were analyzed^d only women who received cryoprecipitate were analyzed

* Insufficient data to perform Wilcoxon signed-rank test.

Table 3

Interventions and Outcomes for Patients with severe Postpartum Hemorrhage during Prelabor Cesarean Delivery

	Severe PPH (n=269)
Pharmacologic treatment	
Oxytocin dose (IU)	33 (1) ^a
Methylergonovine given	89 (33.1%)
Methylergonovine dose (mg)	0.2 [0.2 – 0.2]
Carboprost given	58 (21.6%)
Carboprost dose (mg)	0.25 [0.25 – 0.25]
Misoprostol given	52 (19.3%)
Misoprostol dose (mcg)	800 [600 – 1000]
Medical/Surgical intervention	
B-lynch brace suture	8 (2.9%)
Bakri balloon	22 (8.2%)
Uterine artery ligation	5 (1.9%)
Hypogastric artery ligation	2 (0.7%)
Hysterectomy	47 (17.5%)
Interventional Radiology:	
UA embolization	8 (2.9%)
UA or IA balloon catheterization	10 (3.7%)
Laboratory Indices within 48 h of CD	
Nadir hemoglobin (g/dl)	8.2 (1.5) ^b
Lowest platelet count ($\times 10^9/L$)	148 (54) ^c
Lowest fibrinogen (mg/dl)	272 [185 – 361] ^d
Highest INR	1.2 [1.1 – 1.4] ^e
Highest APTT (s)	33.2 [29.8 – 39.1] ^f
Disposition Post-CD	
ICU	43 (16.1%)
Monitored bed	5 (1.9%)
Routine postpartum bed	219 (82%)
ICU-related morbidity	
Mechanical ventilation	22 (8.2%)
Pulmonary edema	8 (2.9%)
ARDS	1 (0.4%)
Renal failure	1 (0.4%)

Data presented as n (%), mean (SD), median [IQR]

APTT = activated partial thromboplastin time; ARDS = adult respiratory distress syndrome; CD = cesarean delivery; IA = internal iliac artery; ICU = Intensive Care Unit; INR = international normalized ratio; IU = international units; PPH = Postpartum hemorrhage; UA = uterine artery

^aData available for 252 patients

^bData available for 263 patients

^cData available for 234 patients

^dData available for 121 patients

^eData available for 141 patients

^fData available for 137 patients

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Table 4

Characteristics of Women with Severe Postpartum Hemorrhage during Intrapartum Cesarean Delivery

	Severe PPH (n=278)
Maternal age (y)	30 (7)
Weight at delivery (kg)	81 (18)
Insurance ^a	
Private	141 (50.9%)
Government-assisted/Other	137 (49.3%)
Race/Ethnicity	
Non-Hispanic white	69 (24.8%)
Hispanic	116 (41.7%)
Non-Hispanic black	13 (4.7%)
Asian	64 (23%)
Other	16 (5.8%)
Chronic hypertension	11 (4%)
Gestational age at delivery (weeks)	39 [36–40]
Parity	0 [0–1]
Number of prior CDs	
0	243 (87.4%)
1	21 (7.6%)
2	14 (5%)
Type of pregnancy	
Singleton	242 (87%)
Multiple pregnancy	36 (13%)
GDM	51 (18.4%)
Pre-eclampsia	32 (11.5%)
Predelivery Hb (g/dl) ^b	11.8 (1.5)
Type of labor	
Spontaneous	172 (61.9%)
Induction	106 (38.1%)
Oxytocin augmentation	189 (68%)
Chorioamnionitis	56 (20.1%)
Magnesium infusion	38 (13.7%)
Cervical dilatation before delivery	
1–9 cm	204 (73.4%)
10 cm	61 (21.9%)
Missing	13 (4.7%)
Time of Delivery	
Weekday daytime	87 (31.3%)

	Severe PPH (n=278)
Weekday nighttime	61 (21.9%)
Weekend	13 (4.7%)
Mode of anesthesia	
Spinal	40 (14.4%)
CSE	32 (11.5%)
Epidural	181 (65.1%)
General anesthesia	25 (9%)
Type of uterine incision	
Low transverse	267 (96%)
Other	11 (4%)

Data presented as n (%), mean (SD), median [IQR]

^aData available for 271 patients

^bData available for 257 patients

CD = cesarean delivery; D&C = dilatation and curettage; D&E = dilatation and evacuation; GDM = gestational diabetes; Hb = hemoglobin, PLTs = platelet count, PPH = postpartum hemorrhage

Table 5

Transfusion Data among Women with Severe Postpartum Hemorrhage during Intrapartum Cesarean Delivery

	Intraoperative Transfusion	Transfusion in first 48 h postpartum	P-value
Intraoperative transfusion			
Red Blood Cells	51 (18.3%)	122 (43.9%)	<0.001
Number of units transfused ^a	2 [2 – 4]	2 [2 – 2]	0.29
Plasma	28 (10.1%)	36 (12.9%)	0.29
Number of units transfused ^b	2 [2 – 4]	2 [2 – 4.5]	0.92
Platelets	12 (4.3%)	11 (4%)	0.83
Number of units transfused ^c	1 [1 – 2]	1 [1 – 5]	0.31
Cryoprecipitate	5 (1.8%)	12 (4.3%)	0.08
Number of pools transfused ^{d*}	1 [1 – 1]	1.5 [1 – 3]	-

Data presented as n (%), median [IQR]

^a only women who received red blood cells were analyzed^b only women who received plasma were analyzed^c only women who received platelets were analyzed^d only women who received cryoprecipitate were analyzed

* Insufficient data to perform Wilcoxon signed-rank test.

Table 6

Interventions for Patients with Severe Postpartum Hemorrhage undergoing Intrapartum Cesarean Delivery

	Severe PPH (n=278)
Pharmacologic treatment	
Oxytocin dose (IU)	37 (18) ^a
Methylergonovine given	120 (43.2%)
Methylergonovine dose (mg)	0.2 [0.2 – 0.4] ^b
Carboprost given	78 (28.1%)
Carboprost dose (mg)	0.25 [0.25 – 0.5] ^c
Misoprostol given	63 (22.7%)
Misoprostol dose (mcg)	800 [600 – 1000] ^d
Medical/Surgical intervention	
B-lynch brace suture	19 (6.8%)
Bakri balloon	10 (3.6%)
Uterine artery ligation	8 (2.9%)
Hypogastric artery ligation	0
Hysterectomy	11 (4%)
Interventional Radiology:	
UA embolization	3 (1.1%)
UA or IA balloon catheterization	0
Laboratory Indices within 48 h of CD	
Nadir hemoglobin (g/dl)	7.9 (1.5) ^e
Lowest platelet count ($\times 10^9/L$)	148 (50) ^f
Lowest fibrinogen (mg/dl)	319 (12) ^g
Highest INR	1.3 [1.2 – 1.4] ^h
Highest APTT (s)	34.6 [30.7 – 40.6] ⁱ
Disposition Post-CD	
ICU	28 (10.1%)
Monitored bed	9 (3.2%)
Routine postpartum bed	237 (85.3%)
Not documented	4 (1.4%)
ICU-related morbidity	
Mechanical ventilation	17 (6.1%)
Pulmonary edema	16 (5.8%)
ARDS	4 (1.4%)
Renal failure	3 (1.1%)

Data presented as mean (SD), median [IQR], n (%)

APTT = activated partial thromboplastin time; ARDS = adult respiratory distress syndrome; CD = cesarean delivery; IA=internal iliac artery; ICU=Intensive care unit; INR = international normalized ratio; IU=international units; PPH = postpartum hemorrhage; UA = uterine artery

^aData available for 259 patients

^bData available for 119 patients

^cData available for 77 patients

^dData available for 62 patients

^eData available for 277 patients

^fData available for 234 patients

^gData available for 131 patients

^hData available for 145 patients

ⁱData available for 143 patients

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