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Postpartum Hemorrhage Following Vaginal Delivery: Risk Factors and Maternal Outcomes

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Abstract

Background—Limited understanding exists of risk factors for PPH post-vaginal delivery.

Objective—To identify risk factors for PPH post-vaginal delivery within a contemporary obstetric cohort.

Study Design—Retrospective case-control study. PPH was classified by an estimated blood loss ≥ 500 mL. Risk factors for PPH were identified using univariable and multivariable logistic regression. We secondarily investigated maternal outcomes and medical and surgical interventions for PPH management.

Results—The study cohort comprised 159 cases and 318 controls. Compared to a second stage duration <2 hours, a second stage ≥ 3 hours was associated with PPH (Adjusted Odds Ratio=2.3; 95% CI=1.2 – 4.6). No other clinical or obstetric variables were identified as independent risk factors for PPH. Among cases, 4% received red blood cells and 1% required intensive care admission.

Conclusion—Although PPH-related morbidity may be uncommon after vaginal delivery, PPH should be anticipated for women after a second stage ≥3 hours.

Keywords

Postpartum Hemorrhage; Risk Factors; Delivery; Obstetric

INTRODUCTION

Postpartum hemorrhage (PPH), a leading cause of maternal morbidity and mortality,[1, 2] has been occurring with increasing frequency in well-resourced countries.[3] In the United States

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(US), between 1999 and 2008, the rate of severe PPH rose from 1.9 to 4.2 per 1000 deliveries.[4] In response, obstetric agencies, such as the Council on Patient Safety in Women's Health, have been promoting initiatives to reduce rates of PPH.[5, 6] One preventive approach is to identify patients at high-risk for PPH prior to delivery, so that blood components and equipment can be mobilized before bleeding onset.

Based on population-wide studies from well-developed countries, the incidence of PPH after vaginal delivery ranges from 0.8% to 7.9%.[4, 7, 8, 9] With at least two-thirds of US births occurring by vaginal delivery,[10] examining risk factors for PPH in this delivery cohort has important clinical significance for several reasons. Firstly, only a limited number of studies have examined risk factors for PPH after vaginal delivery.[11, 12, 13, 14, 15] Given that recommendations regarding the diagnosis of labor dystocia were revised by the American College of Obstetricians and Gynecologists in 2014,[16] there is a need to re-evaluate risk factors for PPH post-vaginal delivery within a obstetric cohort exposed to contemporary intrapartum care and practices. Secondly, administrative data cannot account for all potentially relevant intrapartum factors, such as oxytocin augmentation. Therefore, studies sourcing granular clinical data are needed to better understand the associations between labor factors and PPH after vaginal delivery. Lastly, medical and surgical approaches to PPH management have changed in recent years. For example, intrauterine balloon tamponade and interventional radiology techniques can be considered for the second line treatment of severe PPH. However, there are limited data on the use of these and other second-line interventions for treating PPH after vaginal delivery.[17, 18] Therefore, studies examining risk factors for PPH, interventions and outcomes after PPH would be valuable in informing current clinical practice.

The primary aim of this study was to investigate risk factors for PPH among women undergoing vaginal delivery. For this study, clinical data were sourced from a contemporary obstetric cohort to account for potentially important intrapartum and labor factors. We secondarily compared rates of medical and surgical interventions as well as postpartum morbidities among women with vs. without PPH after vaginal delivery.

METHODS

After obtaining IRB approval, we performed a retrospective case-control study. To identify our study cohort, we performed an initial search query within our electronic medical record system (EPIC Systems Corp.; Verona, WI) for women who underwent vaginal delivery between May 8, 2014 and September 3, 2015 at Lucile Packard Children’s Hospital, a US tertiary obstetric center in California. Our institution also has 24-hour in-house attending anesthesiologist and obstetrician availability, with immediate access to equipment and resources for PPH management (including a massive transfusion protocol, dedicated operating rooms on the labor and delivery unit, and access to interventional radiology).

At our hospital, vaginal deliveries are performed by a community or hospital-based attending obstetrician, assisted by a labor nurse. Blood loss is measured gravimetrically after each delivery as follows. Placed at the end of the bed, conical drapes collect blood lost during and after each vaginal delivery. A nurse also measures the volume of blood captured

in the drapes and weighs blood soaked laps. Immediately after delivery of the fetus, the most common practice is to administer oxytocin as an intravenous infusion (20 units in 1000 mL of Lactated Ringer's solution), with fundal massage and gentle traction of the umbilical cord to facilitate placental removal.

For the initial cohort, we performed a search query to extract data for blood loss after delivery from each patient's delivery summary (blood loss is estimated by the primary obstetrician at delivery). Based on this initial search, we identified 159 women (2.9%) who experienced PPH. We used a traditional definition for PPH: an estimated blood loss (EBL) ≥500 mL.[19] For each case, we identified two controls (EBL <500 mL) who were delivered vaginally by the same obstetrician closest in time to each matched case. We excluded deliveries occurring before 24 weeks' gestational age, deliveries by cesarean section, and pregnancies resulting in a fetal demise.

Three trained research assistants (SA, SC, CM) manually abstracted detailed maternal and clinical information from each patient's medical record. Based on prior literature review, we selected a number of candidate variables as potential predictors for PPH after vaginal delivery.[11, 12, 13, 15, 20] Patient and obstetric variables considered were: maternal age, body mass index (BMI), insurance type, race/ethnicity, gestational or chronic hypertension, preeclampsia, gestational age at delivery, parity, trial of labor after prior cesarean, singleton/multiple pregnancy, diabetes, and pre-delivery hemoglobin closest time of delivery. Intrapartum variables considered were: type of labor (spontaneous or induced), highest infusion rate of oxytocin before delivery, duration of oxytocin infusion before delivery, chorioamnionitis, intravenous infusion with magnesium sulfate, time of delivery (classified as weekday daytime [between 7 am and 4:59 pm], weekday nighttime [between 5 pm and 6:59 am], and weekend), mode of analgesia (epidural, spinal or combined spinal-epidural, or none), duration of first, second, and third stage of labor, type of delivery (spontaneous or instrumental), episiotomy, and genital tract lacerations.

For our secondary analyses, we assessed rates for the following interventions among cases and controls: second-line uterotonics (methylergonovine maleate, misoprostol, carboprost tromethamine); uterine balloon tamponade; interventional radiological interventions; surgical interventions: vessel ligation, hysterectomy; and blood component use for women who experienced PPH. We also determined the initial location of the postpartum hospitalization (post-partum ward, monitored surgical ward, intensive care unit (ICU)), and the following hemorrhage-related morbidities: respiratory failure, acute respiratory distress syndrome (ARDS), pulmonary edema, renal failure, and maternal death. Data for all secondary outcomes were manually extracted from each patient's medical record.

Statistical Analysis

The distribution of patient characteristics, interventions, blood component usage, and morbidities were compared between cases and controls using Student's t test, Mann-Whitney U test, χ^2 test, and Fisher's Exact Test, as appropriate. Multivariable logistic regression analyses were performed to identify risk factors for PPH. Variables significantly associated with PPH on univariable analyses ($P<0.2$) were considered for inclusion in our multivariable analyses. Because the following continuous variables (BMI, duration of

oxytocin infusion before delivery, highest oxytocin infusion rate, and durations of the first and second stages of labor) had nonlinear associations with the outcome measure, these were included as categorical variables in our models. We applied BMI cut-points based on World Health Organization criteria for obesity: <30, 30–34.9, 35–39.9, and >40.[21] Duration of oxytocin infusion and highest oxytocin infusion rate were categorized into tertiles. The first stage of labor was categorized as follows: <11 hr; 11–15 hr; and ≥16 hr. These cutoff points were representative of the 75th and 90th percentiles for the first stage duration. Based on prior studies, 2 hr and 3 hr were selected as cut-points for the second stage of labor.[22, 23, 24, 25, 26, 27] Model fit was assessed using the Hosmer-Lemeshow goodness of fit test, and discrimination using the area under the receiver operating characteristics curve (AUROC).

We determined that a sample of 459 women would be required to calculate a minimum detectable odds ratio of 2.2 for exposures, with a prevalence of 10% for relevant candidate variables among controls, and a case:control ratio of 1:2 (alpha=0.05 and beta=0.8). Statistical analyses were performed using STATA (Version 12, StataCorp LP, College Station, TX). Statistical significance was determined by a P<0.05.

RESULTS

During the study period, there were a total of 5,905 vaginal deliveries. In our study cohort, we identified 159 cases with PPH and 318 matched controls. Women with PPH had significantly higher EBL compared to controls 600 [500–1000] ml vs. 300 [200–350] ml; P<0.001). Patient characteristics for cases and controls are presented in Table 1. No significant between-group differences were observed for any demographic or obstetric characteristic. Intrapartum characteristics of the study cohort are presented in Table 2. Compared to women without PPH, women with PPH were more likely to have a longer first and second stage of labor, a higher maximum oxytocin infusion rate and a longer duration of oxytocin infusion, receive magnesium therapy, and undergo episiotomy. While there was no significant difference in the duration of the first stage between cases and controls (P=0.17), cases were more likely to experience a longer second stage (P=0.002). Twenty-eight (18%) women with PPH experienced a second stage of ≥3 hr compared to 24 (8%) controls.

We observed collinearity between duration of oxytocin infusion and highest oxytocin infusion rate (spearman correlation coefficient rho=0.72). Therefore, we selected duration of oxytocin infusion in our logistic models because of the variable timing of the highest oxytocin infusion rate prior to delivery. Variables included in our multivariable analyses were: BMI, parity, chorioamnionitis, magnesium infusion, duration of oxytocin infusion, durations of the first and second stages of labor, and episiotomy. Multiple pregnancy and type of labor (spontaneous vs. induced) were forced into the final multivariable model since these variables have previously been shown to be associated with increased risk of PPH.[11, 12, 13] Results from the multivariable analysis are presented in Table 3. In our multivariable analysis, women with a second stage duration ≥3 hr had an increased odds of PPH (aOR=2.32; 95% CI=1.16–4.63) compared to those with a second stage duration <2 hr. Women who received 1 – 7 hr oxytocin had a decreased odds of PPH, but confidence intervals were wide (aOR=0.53; 95% CI=0.30–0.92). The AUROC was modest (0.64).

Because second stage duration may be influenced by neuraxial labor analgesia, in our final model we performed a sensitivity analysis which accounted for neuraxial blockade. Inclusion of this variable did not alter point estimates for the association between PPH and second stage duration (data not presented). We also examined whether second stage duration influenced PPH according to parity (Table 4). Among nulliparous women, those who a second stage duration of ≥3 hr had a greater likelihood of PPH compared to those with a second stage duration <2 hr or 2 – 2.9 hr (P=0.04). In contrast, among multiparous women, few women had a second stage duration ≥2 hr, and no significant differences were observed in PPH rates according to second stage duration (P=0.27).

Secondary Analyses

Data for medical and surgical interventions are presented in Table 5. Among PPH cases, the frequency of methylergonovine and misoprostol use was 47% and 36% respectively, suggesting that refractory uterine atony was a common PPH etiology. The median dose administered for each second-line uterotonic (200 mcg methylergonovine, 250 mcg carboprost, 800 mcg misoprostol) suggests that repeat dosing for each uterotonic was uncommon. Few patients required surgical intervention for PPH control, with 13 cases receiving vaginal packing and one case requiring interventional radiologic intervention.

Postpartum blood component utilization among cases was low. Within 6 hr after delivery, only 7 (4.4%) patients received red blood cells, 4 (2.5%) patients received plasma, 1 (0.6%) patient received platelets, and 1 (0.6%) patient received cryoprecipitate. More than 6 hr after delivery, 9 (5.7%) patients received red blood cells and no other types of blood components were transfused.

DISCUSSION

In this retrospective case-control study of women undergoing vaginal delivery, we examined risk factors for PPH as well as interventions and outcomes after PPH. Our study has several strengths, including: clinical data that were sourced from medical records by trained research investigators, a demographically diverse obstetric population, and recent delivery hospitalization data which account for contemporary obstetric and anesthetic practices. We observed that a second stage duration of ≥ 3 hr was the only independent risk factor for PPH. Among women who experienced PPH, second line uterotonic use was relatively high, but few patients required surgical intervention or postpartum transfusion.

Other studies have identified other risk factors for PPH after vaginal delivery, including episiotomy, multiple gestation, and prolonged first stage duration.[11, 12, 13, 14, 15] Yet, in our multivariable models, these variables were not identified as risk factors for PPH. Among studies investigating risk factors for PPH after vaginal delivery, differences in PPH risk profiles may be due to: dissimilar patient and obstetric characteristics across study populations, dates of study period, choice and classification of candidate variables and PPH criteria, and selected regression modeling approaches. Furthermore, obstetric practices for managing the first and second stage of labor differ between institutions and have changed over time, which may explain why a prolonged second stage of labor was the only independent risk factor identified in our study.

Our findings provide further evidence of a positive association between second stage duration and PPH risk. Data from other studies support this association. In a population-based cohort study in Canada, Allen et al. found that, among nulliparous women, the risk of PPH increased with each hour of the second stage after 2 hr compared with a duration ≤2 hr.[22] In a retrospective cohort study, Laughon et al. observed that, among nulliparous women who underwent epidural labor analgesia and non-operative vaginal delivery, a second stage >2hr was associated with a 1.5 fold increased risk of PPH compared to a duration ≤2 hr.[28] In a retrospective cohort study, Cheng et al. reported that, among nulliparous women, for each 1 hr increase in second stage duration, the adjusted odds of PPH increases by 16%.[26] These findings have important clinical relevance because of recent changes in the acceptable upper time limits for the second stage. In a document entitled “Safe prevention of the primary cesarean delivery”, the American Congress of Obstetricians and Gynecologists and the Society for Maternal Fetal Medicine have jointly recommended that arrest of the second stage be diagnosed at least 3 h of pushing in nulliparous women without epidural analgesia, and that ‘longer durations may be appropriate on an individualized basis’.[16] Although the main remit for these recommendations is to reduce the incidence of intrapartum cesarean delivery, the unintended consequence may be an increase in PPH frequency after vaginal delivery. Further studies are needed to determine whether the risk increase is related to second stage duration, or to interventions that occur in response to a prolonged second stage such as, instrumental delivery or episiotomy.

An intriguing study finding was that women who received a 1–7 hr duration of oxytocin augmentation had a 59% reduced odds of PPH compared to those not exposed to intrapartum oxytocin. In contrast to our findings, other studies have found longer durations of oxytocin infusion to be associated with an increased risk of PPH. Belghiti et al. observed that women who were exposed to oxytocin for ≥7 hr oxytocin had a 1.8 fold increased risk of PPH, compared to women unexposed to exogenous oxytocin.[29] Grotegut et al. reported that, compared to matched controls, women experiencing PPH received significantly longer periods of oxytocin augmentation (10.5 hr vs. 4.9 hr).[30] However, the maximum rates of oxytocin infusion associated with PPH in these studies were much higher than the maximum infusion rates in our cohort. We speculate that either a short duration of oxytocin augmentation or exposure to a low oxytocin infusion rate may increase the strength and/or frequency of uterine contractions and potentially shorten the duration of labor without inducing oxytocin receptor desensitization. Further studies are needed to examine the dose-response effect of an oxytocin infusion for labor augmentation on PPH risk.

Among women experiencing PPH, rates were low for blood component utilization and medical/surgical interventions for hemorrhage control. It is unclear whether this is because early recognition and treatment (with uterotonics) mitigated severe blood loss or because the magnitude of blood loss was non-severe (median EBL=600 ml). Methylergonovine may be the most commonly used second-line uterotonic for treating atonic PPH in the United States. In a prior study of 2.1 million women hospitalized for delivery, methylergonovine use was more common than carboprost.[31] Methylergonovine may also be more efficacious than other second-line uterotonics. In an observational study examining 1335 women undergoing cesarean delivery who developed refractory uterine atony, women who received methylergonovine were at reduced risk of hemorrhage-related morbidity compared to those

who received carboprost.[32] Our findings extend these results, suggesting that methylergonovine is the preferred second-line uterotonic after vaginal delivery.

We acknowledge that our study has several weaknesses. Limitations inherent to an observational study design apply to our study. Because our study cohort was sourced from women who delivered at a single tertiary obstetric center, the generalizability of our findings is uncertain. Data on the second stage of labor did not account for the expulsive versus non-expulsive phase, and thus it is possible that second stage durations were overestimated. We did not account for multiple testing in our sample size estimation, therefore the minimum detectable odds ratios for candidate variables in each multivariable model may have been underestimated. The AUROCS in our logistic models were modest suggesting that there are unmeasured factors that may influence the risk of PPH. For instance, we were not able to consider information about oxytocin dose administered after delivery for prophylaxis against uterine atony, because these data were not available in the electronic medical records. We could not account for all women intending vaginal delivery in our study cohort. Therefore, we could not consider those who underwent intrapartum cesarean delivery following an unsuccessful trial of labor or induction. Lastly, heterogeneity may exist among obstetric providers for the following key practices that may influence PPH incidence and severity: blood loss quantification, indications for initiating oxytocin for labor augmentation, prophylaxis against uterine atony, and criteria for using second-line uterotonics for PPH treatment.

In this retrospective case-control study, we observed that women with a second stage of labor lasting ≥3 hr had two fold-increased odds of PPH compared to those whose second stages were <2 hr. In light of recent changes to the upper acceptable limits for second stage duration, PPH risk may be increased if second stage duration exceeds 3 hr. The low rate of hemorrhage-related morbidity suggests outcomes are favorable for most women who experience PPH after vaginal delivery. However, vigilance is still needed because severe PPH after vaginal delivery is infrequent and often unexpected.

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REFERENCES

1. Callaghan WM, Creanga AA, Kuklina EV. Severe maternal morbidity among delivery and postpartum hospitalizations in the United States. Obstet Gynecol. 2012; 120(5):1029–1036. [PubMed: 23090519]
2. Creanga AA, Bateman BT, Butwick AJ, Raleigh L, Maeda A, Kuklina E, et al. Morbidity associated with cesarean delivery in the United States: is placenta accreta an increasingly important contributor? Am J Obstet Gynecol. 2015; 213(3):384 e381–384 e311. [PubMed: 25957019]
3. Knight M, Callaghan WM, Berg C, Alexander S, Bouvier-Colle MH, Ford JB, et al. Trends in postpartum hemorrhage in high resource countries: a review and recommendations from the International Postpartum Hemorrhage Collaborative Group. BMC Pregnancy Childbirth. 2009; 9:55. [PubMed: 19943928]

4. Kramer MS, Berg C, Abenhaim H, Dahhou M, Rouleau J, Mehrabadi A, et al. Incidence, risk factors, and temporal trends in severe postpartum hemorrhage. Am J Obstet Gynecol. 2013; 209(5): 449 e441–449 e447. [PubMed: 23871950]
5. California Maternal Quality Care Collaborative. Obstetric Hemorrhage Toolkit: Improving Health Care Response to Obstetric Hemorrhage. [Accessed 10/21/2016] https://www.cmqcc.org/ob_hemorrhage/ob_hemorrhage_compendium_of_best_practices.
6. Council on Patient Safety in Women's Health Care. [Accessed 10/21/16] Available at: http://www.safehealthcareforeverywoman.org/default.php.
7. Al-Zirqi I, Vangen S, Forsen L, Stray-Pedersen B. Prevalence and risk factors of severe obstetric haemorrhage. BJOG. 2008; 115(10):1265–1272. [PubMed: 18715412]
8. Lutomski JE, Byrne BM, Devane D, Greene RA. Increasing trends in atonic postpartum haemorrhage in Ireland: an 11-year population-based cohort study. BJOG. 2012; 119(3):306–314. [PubMed: 22168794]
9. Mehrabadi A, Hutcheon JA, Lee L, Kramer MS, Liston RM, Joseph KS. Epidemiological investigation of a temporal increase in atonic postpartum haemorrhage: a population-based retrospective cohort study. BJOG. 2013; 120(7):853–862. [PubMed: 23464351]
10. Hamilton BE, Martin JA, Osterman MJ, Curtin SC, Matthews TJ. Births: Final Data for 2014. National vital statistics reports : from the Centers for Disease Control and Prevention, National Center for Health Statistics, National Vital Statistics System. 2015; 64(12):1–64.
11. Combs CA, Murphy EL, Laros RK Jr. Factors associated with postpartum hemorrhage with vaginal birth. Obstet Gynecol. 1991; 77(1):69–76. [PubMed: 1984230]
12. Wetta LA, Szychowski JM, Seals S, Mancuso MS, Biggio JR, Tita AT. Risk factors for uterine atony/postpartum hemorrhage requiring treatment after vaginal delivery. Am J Obstet Gynecol. 2013; 209(1):51 e51–51 e56. [PubMed: 23507549]
13. Magann EF, Evans S, Hutchinson M, Collins R, Howard BC, Morrison JC. Postpartum hemorrhage after vaginal birth: an analysis of risk factors. South Med J. 2005; 98(4):419–422. [PubMed: 15898516]
14. Biguzzi E, Franchi F, Ambrogi F, Ibrahim B, Bucciarelli P, Acaia B, et al. Risk factors for postpartum hemorrhage in a cohort of 6011 Italian women. Thromb Res. 2012; 129(4):e1–e7. [PubMed: 22018996]
15. Buzaglo N, Harlev A, Sergienko R, Sheiner E. Risk factors for early postpartum hemorrhage (PPH) in the first vaginal delivery, and obstetrical outcomes in subsequent pregnancy. J Matern Fetal Neonatal Med. 2015; 28(8):932–937. [PubMed: 25023434]
16. American College of Obstetricians and Gynecologists, Society for Maternal-Fetal Medicine, et al. Safe prevention of the primary cesarean delivery. Obstet Gynecol. 2014; 123(3):693–711. [PubMed: 24553167]
17. Postpartum hemorrhage. ACOG Practice Bulletin No. 76. American College of Obstetricians and Gynecologists. Obstet Gynecol. 2006; 108(4):1039–1047. [PubMed: 17012482]
18. Kayem G, Kurinczuk JJ, Alfirevic Z, Spark P, Brocklehurst P, Knight M. Specific second-line therapies for postpartum haemorrhage: a national cohort study. BJOG. 2011; 118(7):856–864. [PubMed: 21392247]
19. Rath WH. Postpartum hemorrhage--update on problems of definitions and diagnosis. Acta Obstet Gynecol Scand. 2011; 90(5):421–428. [PubMed: 21332452]
20. Burrows LJ, Meyn LA, Weber AM. Maternal morbidity associated with vaginal versus cesarean delivery. Obstet Gynecol. 2004; 103(5 Pt 1):907–912. [PubMed: 15121564]
21. Obesity: preventing and managing the global epidemic. Report of a WHO consultation. World Health Organ Tech Rep Ser. 2000; 894:i–xii. 1–253. [PubMed: 11234459]
22. Allen VM, Baskett TF, O'Connell CM, McKeen D, Allen AC. Maternal and perinatal outcomes with increasing duration of the second stage of labor. Obstet Gynecol. 2009; 113(6):1248–1258. [PubMed: 19461419]
23. Saunders NS, Paterson CM, Wadsworth J. Neonatal and maternal morbidity in relation to the length of the second stage of labour. Br J Obstet Gynaecol. 1992; 99(5):381–385. [PubMed: 1622909]

24. Myles TD, Santolaya J. Maternal and neonatal outcomes in patients with a prolonged second stage of labor. Obstet Gynecol. 2003; 102(1):52–58. [PubMed: 12850607]

25. Li WH, Zhang HY, Ling Y, Jin S. Effect of prolonged second stage of labor on maternal and neonatal outcomes. Asian Pac J Trop Med. 2011; 4(5):409–411. [PubMed: 21771687]

26. Cheng YW, Hopkins LM, Caughey AB. How long is too long: Does a prolonged second stage of labor in nulliparous women affect maternal and neonatal outcomes? Am J Obstet Gynecol. 2004; 191(3):933–938. [PubMed: 15467567]

27. Altman M, Sandstrom A, Petersson G, Frisell T, Cnattingius S, Stephansson O. Prolonged second stage of labor is associated with low Apgar score. Eur J Epidemiol. 2015; 30(11):1209–1215. [PubMed: 26008749]

28. Laughon SK, Berghella V, Reddy UM, Sundaram R, Lu Z, Hoffman MK. Neonatal and maternal outcomes with prolonged second stage of labor. Obstet Gynecol. 2014; 124(1):57–67. [PubMed: 24901265]

29. Belghiti J, Kayem G, Dupont C, Rudigoz RC, Bouvier-Colle MH, Deneux-Tharaux C. Oxytocin during labour and risk of severe postpartum haemorrhage: a population-based, cohort-nested case-control study. BMJ Open. 2011; 1(2):e000514.

30. Grotegut CA, Paglia MJ, Johnson LN, Thames B, James AH. Oxytocin exposure during labor among women with postpartum hemorrhage secondary to uterine atony. Am J Obstet Gynecol. 2011; 204(1):56 e51–56 e56. [PubMed: 21047614]

31. Bateman BT, Tsen LC, Liu J, Butwick AJ, Huybrechts KF. Patterns of second-line uterotonic use in a large sample of hospitalizations for childbirth in the United States: 2007–2011. Anesth Analg. 2014; 119(6):1344–1349. [PubMed: 25166464]

32. Butwick AJ, Carvalho B, Blumenfeld YJ, El-Sayed YY, Nelson LM, Bateman BT. Second-line uterotonics and the risk of hemorrhage-related morbidity. Am J Obstet Gynecol. 2015; 212(5):642 e641–642 e647. [PubMed: 25582104]

Table 1

Patient Characteristics

Characteristic	Cases (n=159)	Controls (n=318)	P value
Maternal age (yr)	31 [27–35]	32 [27–35]	0.57
BMI (kg/m^2)[a]			0.48
< 30	96 (62.3%)	202 (66.0%)	
30 – 34.9	36 (23.5%)	71 (23.2%)	
35 – 39.9	13 (8.4%)	24 (7.9%)	
≥ 40	9 (5.8%)	9 (2.9%)	
Insurance			0.24
Private	111 (69.8%)	205 (64.5%)	
Government-assisted/Other	48 (30.2%)	113 (35.5%)	
Race/Ethnicity			0.33
Hispanic	58 (36.5%)	109 (34.3%)	
Non-Hispanic White	42 (26.4%)	105 (33.0%)	
Asian	48 (30.2%)	77 (24.2%)	
Non-Hispanic Black/Other	11 (6.9%)	27 (8.5%)	
Hypertension (gestational or chronic)	9 (5.7%)	19 (6.0%)	0.89
Gestational age at delivery (wks)[b]	39.4 [38.4–40.1]	39.3 [38.3–40.1]	0.30
Parity			0.07
0	95 (59.7%)	162 (50.9%)	
≥ 1	64 (40.3%)	156 (49.1%)	
TOLAC	5 (3.1%)	11 (3.5%)	1.0
Type of pregnancy			1.0
Singleton	149 (93.7%)	298 (93.7%)	
Multiple pregnancy	10 (6.3%)	20 (6.3%)	
Diabetes (pre-existing or GDM)	27 (17.0%)	47 (14.8%)	0.53
Pre-eclampsia	12 (7.5%)	16 (5.0%)	0.27
Predelivery Hb (g/dl)[c]	12.3 (1.2)	12.4 (1.2%)	0.40

Data presented as n (%), median [interquartile range]

BMI = Body Mass Index; GDM = gestational diabetes; Hb = hemoglobin; TOLAC = trial of labor after cesarean

[a] Data missing for 5 cases and 12 controls

[b] Data missing for 1 case and 1 control

[c] Data missing for 35 cases and 59 controls

Table 2

Intrapartum Characteristics

Characteristic	Cases (n=159)	Controls (n=318)	P value
Type of labor:			0.21
Spontaneous	96 (60.4%)	215 (67.6%)	
Induction	63 (39.6%)	103 (32.4%)	
Duration 1st stage labor (hr)[a]			
< 11	90 (72.0%)	199 (78.7%)	0.17
11–15.9	17 (13.6%)	33 (13.0%)	
≥ 16	18 (14.4%)	21 (8.3%)	
Duration 2nd stage labor (hr)[b]			0.002
0 – 1.9	109 (70.3%)	257 (82.1%)	
2 – 2.9	18 (11.6%)	32 (10.2%)	
≥ 3	28 (18.1%)	24 (7.7%)	
Duration 3rd stage labor (min)[c]	5 [3 – 8]	5 [3 – 7]	0.58
Oxytocin augmentation	95 (59.8%)	203 (63.8%)	0.38
Highest oxytocin infusion rate before delivery (mU/min)			0.002
0	64 (40.3%)	116 (36.5%)	
1 – 7	32 (20.1%)	111 (34.9%)	
≥ 8	63 (39.6%)	91 (28.6%)	
Duration of oxytocin augmentation (hr)			0.008
0	64 (40.3%)	116 (36.5%)	
1 – 7	32 (20.1%)	106 (33.3%)	
≥ 7.1	63 (39.6%)	96 (30.2%)	
Chorioamnionitis	15 (9.4%)	22 (6.9%)	0.35
Magnesium infusion	20 (12.6%)	21 (6.6%)	0.03
Time of delivery			0.79
Weekday daytime	40 (25.2%)	88 (27.7%)	
Weekday nighttime	69 (43.4%)	138 (43.4%)	
Weekend	50 (31.5%)	92 (28.9%)	
Mode of anesthesia			0.46
None	36 (22.6%)	58 (18.2%)	
Epidural	79 (49.7%)	160 (50.3%)	
Spinal or CSE	44 (27.7%)	100 (31.5%)	
Type of delivery			0.29
Spontaneous	139 (87.4%)	288 (90.6%)	
Instrumental (Forceps or Suction)	20 (12.6%)	30 (9.4%)	

Characteristic	Cases (n=159)	Controls (n=318)	P value
Episiotomy	14 (8.8%)	13 (4.1%)	0.04
Genital tract laceration[d]	117 (73.6%)	240 (75.5%)	0.61

Data presented as n (%), median [interquartile range]

CSE=combined spinal-epidural

[a]Data missing for 34 cases and 65 controls

[b]Data missing for 4 cases and 9 controls

[c]Data missing for 1 case and 9 controls

[d]Data missing for 1 control

Table 3

Multivariable analysis

	Adjusted Odds Ratio (95% CI)*
Maternal BMI (kg/m^2):	
< 30	Reference
30 – 34.9	1.15 (0.69 – 1.90)
35 – 39.9	1.01 (0.45 – 2.25)
≥ 40	2.66 (0.98 – 7.21)
Multiple pregnancy	0.96 (0.42 – 2.19)
Parity	
0	Reference
≥ 1	0.84 (0.53 – 1.33)
Type of labor	
Spontaneous	Reference
Induced	1.40 (0.86 – 2.30)
Chorioamnionitis	1.02 (0.47 – 2.22)
Magnesium infusion	1.44 (0.70 – 2.97)
Duration of oxytocin augmentation (hr)	
0	Reference
1–7	**0.53 (0.30 – 0.92)**
≥ 7.1	0.80 (0.45 – 1.44)
Duration 1st stage labor (hr)	
< 11	Reference
11–15.9	1.14 (0.58 – 2.25)
≥ 16	1.55 (0.73 – 3.31)
Missing	1.04 (0.61 – 1.78)
Duration 2nd stage labor (hr)	
0 – 1.9	Reference
2 – 2.9	1.17 (0.58 – 2.37)
≥ 3	**2.32 (1.16 – 4.63)**
Episiotomy	1.80 (0.77 – 4.21)

BMI = body mass index

*Point estimates in bold represent variables independently associated with postpartum hemorrhage.

Table 4

Rates of Postpartum Hemorrhage According to Duration of the Second Stage of Labor, stratified by Parity.

	Nulliparous		Multiparous	
Duration of Second Stage	**No PPH (n=159)**	**PPH (n=91)**	**No PPH (n=89)**	**PPH (n=36)**
<2 hr	109 (68.6%)	51 (56%)	86 (96.6%)	34 (94.4%)
2 – 2.9 hr	28 (17.6%)	16 (17.6%)	2 (2.2%)	0
≥ 3hr	22 (13.8%)	24 (26.4%)	1 (1.1%)	2 (5.6%)

Data presented as n (%).

PPH = postpartum hemorrhage

Table 5

Pharmacologic Treatment and Medical and Surgical Interventions for Patients with and without Postpartum Hemorrhage during Vaginal Delivery

	PPH (n=159)	No PPH (n=318)	P value
Pharmacologic treatment			
Methylergonovine	75 (47.2%)	8 (2.5%)	<0.001
Total dose up to 24 hr after delivery (mcg)[a]	200 [200-200]	200 [200-200]	0.185
Carboprost	19 (12.0%)	0 (0.0%)	-
Total dose up to 24 hr after delivery (mcg)	250 [250-250][b]	-	-
Misoprostol	57 (35.9%)	12 (3.8%)	<0.001
Total dose up to 24 hr after delivery (mcg)[c]	800 [800-800]	800 [600–900]	0.741
Vessel ligation	0 (0.0%)	0 (0.0%)	-
Vaginal packing	13 (8.2%)	0 (0.0%)	<0.001
Hysterectomy	0 (0.0%)	0 (0.0%)	-
Interventional Radiology:			
UA embolization	0 (0.0%)	0 (0.0%)	-
UA or IA balloon catheterization	1 (0.6%)	0 (0.0%)	0.333
Disposition Post-Delivery			
ICU	2 (1.3%)	1 (0.3%)	0.259
Severe morbidity			
Respiratory failure requiring ventilation	2 (1.3%)	0 (0.0%)	0.111
Pulmonary edema	3 (1.9%)	1 (0.3%)	0.110
ARDS	0 (0.0%)	0 (0.0%)	-
Renal failure	0 (0.0%)	0 (0.0%)	-

[a] Data available for 75 cases and 8 controls

[b] Data available for 19 patients

[c] Data available for 57 cases and 12 controls

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

ARDS = adult respiratory distress syndrome; IA=internal iliac artery; ICU=intensive care unit; PPH = postpartum hemorrhage; UA = uterine artery