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Hemorrhage-related maternal morbidity of secondary compared to primary postpartum hemorrhage

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Abstract

Objectives: To compare a composite hemorrhage-related maternal morbidity in individuals with secondary to primary postpartum hemorrhage and treatment interventions utilized.

Methods: A retrospective case-control study of deliveries complicated by secondary postpartum hemorrhage was performed at a tertiary care center. To estimate a clinically relevant increase of 50 % in the composite maternal hemorrhage-related maternal morbidity (35–53 % absolute increase) in individuals with secondary postpartum hemorrhage, a correlation coefficient of 0.2, at an 80 % power with a $p < 0.05$ with a two-sided test would require 95 individuals with secondary postpartum hemorrhage be matched to 95 individuals with a primary postpartum hemorrhage. Logistic regression analysis was used to evaluate the outcome of the composite of hemorrhage-related maternal morbidity.

Results: From January 2018 through December 2022, 33,026 deliveries occurred, and 94 individuals were identified that were admitted with secondary postpartum hemorrhage, 0.28 % of deliveries, 95 % confidence interval (CI) 0.21–0.35 %. The composite hemorrhage-related maternal morbidity was increased in individuals with secondary compared to primary postpartum hemorrhage, adjusted odds ratio (OR) 14.0, 95 % CI 4.6 to 42.2. Most individuals with secondary postpartum hemorrhage had a dilation and curettage 91.5 % (86/94). In individuals with secondary postpartum hemorrhage that underwent uterine evacuation, histology revealed 45.2 % (38/84) had retained placenta, and 20.2 % (17/84) subinvolution.

Conclusions: A composite maternal hemorrhage-related outcome is associated more often with secondary compared to primary postpartum hemorrhage and nearly all individuals with secondary postpartum hemorrhage undergo a dilation and curettage.

Keywords: secondary postpartum hemorrhage; primary postpartum hemorrhage; morbidity

Introduction

Maternal hemorrhage is a significant cause of pregnancy-related deaths, accounting for 12.1 % of maternal mortality in the United States [1]. In 2019, primary postpartum hemorrhage was estimated to occur in 4.3 % of deliveries in the United States [2]. Individuals experiencing primary postpartum hemorrhage have a 42 % higher risk for readmission for recurrent postpartum hemorrhage within 60 days of delivery when compared to those who do not have a postpartum hemorrhage [3]. Secondary postpartum hemorrhage, defined as excessive bleeding that occurs more than 24 h after delivery but within 12 weeks following delivery affects less than 1 % of all deliveries, but remains a life-threatening delivery complication [4, 5]. Individuals with secondary postpartum hemorrhage compared to those without any postpartum hemorrhage experience significantly more hospital admissions, emergency room visits, and outpatient encounters resulting in a 9.5-fold increase in postpartum costs per person [6]. With few risk factors to identify individuals at greatest risk for this condition, care must focus on prompt diagnosis of the underlying cause and appropriate treatment [7].

Despite longstanding recognition of secondary postpartum hemorrhage as a morbid maternal condition, ideal diagnostic and treatment pathways are not well documented. Studies evaluating secondary postpartum

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hemorrhage either have been descriptive or have compared outcomes to deliveries without postpartum hemorrhage [7–16]. The volume of blood loss and treatment interventions for secondary postpartum hemorrhage have not been compared to women with primary postpartum hemorrhage. Thus, information that is available to both healthcare professionals and patients who present with secondary postpartum hemorrhage is limited. Our objective is to compare a composite hemorrhage-related maternal morbidity in individuals with secondary to those with primary postpartum hemorrhage. Our secondary objective was to estimate if interventions utilized to treat a secondary vs. primary postpartum hemorrhage differed.

Materials and methods

This analysis is a retrospective case-control study of individuals experiencing a secondary postpartum hemorrhage following a delivery greater than 20 weeks' gestation delivering between January 1, 2018, and December 31, 2022, at the Texas Children's Hospital. This site is a tertiary care center in Houston, Texas affiliated with the Baylor College of Medicine. A computerized search of medical records dated from January 1, 2018, to December 31, 2022, identified individuals admitted to the hospital with secondary postpartum hemorrhage following delivery. Each case of secondary postpartum hemorrhage was temporally matched in a 1:1 ratio to the next consecutive control patient admitted for delivery who subsequently developed a primary postpartum hemorrhage, using the admission date as the matching criterion. Cases and controls were identified using diagnosis codes in the International Classification of Disease, 10th Revision, Clinical Modification (ICD-10-CM) codes for discharges (Supplementary Material, Appendix 1). The Current Procedural Terminology code for hysterectomy with cesarean delivery, postpartum hysterectomy following vaginal delivery, and dilation and curettage were utilized over the 5-year study period to identify any additional cases of secondary postpartum hemorrhage not identified by ICD-10-CM diagnosis codes. The medical records were then reviewed by the authors to confirm cases of secondary and primary postpartum hemorrhage.

All individuals who underwent hospital admission with a secondary postpartum hemorrhage, and as defined by the American College of Obstetricians and Gynecologists as "excessive bleeding that occurs more than 24 h after delivery and up to 12 weeks postpartum" were included in the study [4]. Control cases of primary postpartum hemorrhage were defined as a delivery with an estimated blood loss greater than or equal to 1,000 mL or symptoms of hypovolemia within 24 h after the birth process (includes intrapartum loss) regardless of route of delivery [4]. Patients with postpartum hemorrhage (either primary or secondary) were excluded if there was documented knowledge of a placenta previa or placenta accreta spectrum diagnosis before delivery. Variables extracted from all reviewed medical records included the following: maternal characteristics (age, body mass index at delivery, race, ethnicity) and obstetric history at the time of the postpartum hemorrhage (gestational age at delivery, gestational plurality, parity, admission hemoglobin), mode of delivery, and specific interventions related to postpartum hemorrhage. Race and ethnicity were obtained from the medical record and were self-designated by the patient. For any surgical specimens obtained, pathology diagnoses were reviewed and recorded for all surgical specimens.

The study's primary outcome was the rate of a composite of hemorrhage-related maternal morbidity or procedures related to management of maternal health previously published (maternal death, hysterectomy, intensive care unit admission, blood transfusion, or unanticipated procedures to treat postpartum bleeding, which includes B-Lynch procedure, uterine artery ligation, hypogastric artery ligation, uterine Bakri placement, dilation and curettage, or laparotomy) [17]. The primary outcome was a count per item but was only counted as one item if there were more than one hemorrhage-related morbidity event or procedure per patient. Secondary outcomes included: estimated blood loss (calculated using a combination of physician and nursing documentation from January 2018 through July 2019, then by quantitative blood loss from August 2019 through December 2022), and uterotonic use. The use of uterotonics excluded the hospital's standardized postdelivery oxytocin infusion and included the use of misoprostol, methylergonovine, or carboprost tromethamine. Analysis of the pathologic diagnosis from surgical specimens was planned between the two groups. For tissue obtained from dilation and curettage, if the histology noted a microscopic or focal placenta accreta, the specimen was assigned to the category of placental accreta. If histology noted both subinvolution and any placental fragments, the case was assigned to the category of retained placenta alone [18]. For all outcomes, individuals with a secondary postpartum hemorrhage were compared with those with a primary one.

We hypothesized that individuals with a secondary postpartum hemorrhage would have a greater maternal hemorrhage-related morbidity when compared to individuals with a primary postpartum hemorrhage [14, 15]. We used a baseline rate of 35 % for the composite maternal hemorrhage-related morbidity after primary postpartum hemorrhage as reported by Gerard et al. [19]. To estimate a

clinically relevant increase of 50 % in the composite maternal hemorrhage-related maternal morbidity (35–53 % absolute increase) in individuals with secondary postpartum hemorrhage, a correlation coefficient of 0.2, at an 80 % power with a $p < 0.05$ would require 95 individuals with secondary postpartum hemorrhage be matched to 95 individuals with a primary postpartum hemorrhage [20]. The reported range of the incidence for secondary postpartum hemorrhage is 0.20–1.6 % [10, 16]. Our institution averages 6,500 deliveries per year and we estimated that at least 5 years of deliveries would need to be evaluated to obtain the calculated sample size for secondary postpartum hemorrhage.

The Wilcoxon signed-rank test for continuous variables and the McNemar test for categorical variables were used to compare baseline demographic and clinical features between secondary vs. primary postpartum hemorrhage matched groups. Logistic regression analysis was used to evaluate the outcome of the composite of hemorrhage-related maternal morbidity and included any independent variables that the univariate analysis noted a $p < 0.10$. These variables were simultaneously entered into a multivariable logistic regression model to account for potential confounders. A stepwise approach was employed for confounder elimination and adjustment of factors, allowing for the extraction of the most significant variables. MedCalc statistical software version 22.030 was used. All tests were 2-tailed, and a $p < 0.05$ was considered statistically significant. A correction for multiple comparisons was not performed. This study was approved by the Institutional Review Board at the Baylor College of Medicine (protocol H-48600). This retrospective analysis was organized following the Strengthening the Reporting of Observational Studies in Epidemiology statement for case-control studies [21].

Results

From January 2018 through December 2022, 33,026 deliveries occurred, and the incidence of primary postpartum hemorrhage was 6.5 % (2,155/33,026). During this time, 97 individuals with a diagnosis of secondary postpartum hemorrhage were admitted. After review of the medical records, three cases were excluded out of concern for an incorrect diagnosis due to no report of vaginal bleeding being reported (one with abdominal pain and two with fever only). The remaining 94 cases comprised 0.28 % of deliveries, 95 % Confidence Interval [CI] 0.21–0.35 %. The median time interval between a woman's date of admission for secondary postpartum hemorrhage and the next control woman's delivery for a primary postpartum hemorrhage was 4 days (interquartile range 2–7 days). Individuals with secondary postpartum hemorrhage were likely to be older, of lower body mass index, of non-Hispanic ethnicity, at a lower gestational age at delivery, with a higher rate of twin gestation, vaginal delivery, and have a manual extraction of the placenta when compared to individuals with a primary postpartum hemorrhage (Table 1). Maternal race, parity, admission hemoglobin level, and the degree of vaginal laceration with vaginal delivery did not differ between groups. Individuals admitted with a secondary postpartum hemorrhage were noted to have experienced a primary postpartum hemorrhage 29.8 % (28/94) at the time of their delivery. For comparison, in individuals with a primary postpartum hemorrhage that had a prior delivery (*n*=44), 25.0 % (11/44) reported having a postpartum hemorrhage with a previous delivery.

Individuals with secondary postpartum hemorrhage presented at a median of 17 days, (interquartile range 9–31 days) following their delivery. A pelvic ultrasound was performed in 93.6 % (88/94) of individuals at the time of

Table 1: Sociodemographic and delivery features.

Characteristic[a]	Secondary postpartum hemorrhage	Primary postpartum hemorrhage	p-Value
	n=94	n=94	
Age years	32.0 [29.0–35.0]	28.0 [25.0–33.0]	<0.001
Gravidity	2.0 [1.0–3.0]	2.0 [1.0–3.0]	0.41
Parity	1.0 [0–2.0]	0 [0–1.0]	0.22
BMI kg/m^2	29.5 [26.1–35.7]	33.5 [29.1–40.2]	<0.001
Asian race	5 (5.3 %)	4 (4.3 %)	1.0
Black race	12 (12.8 %)	21 (22.3 %)	0.12
White race	75 (79.8 %)	68 (72.3 %)	0.31
Other race[b]	2 (2.1 %)	1 (1.1 %)	1.0
Hispanic ethnicity	30 (31.9 %)	47 (50.0 %)	0.03
EGA @ delivery (weeks)	38.0 [36.6–39.6]	39.1 [37.3–40.0]	0.002
Multiple gestation	9 (9.6 %)	4 (4.3 %)	<0.001
Hgb on admission gm/dl	11.4 [10.3–12.4]	11.4 [10.7–12.5]	0.24
Vaginal delivery	59 (62.8 %)	35 (37.2 %)	<0.001
Degree of laceration in vaginal delivery	2 [0 to 2]	1 [0 to 2]	0.35
Manual removal of placenta	20 (21.3 %)	6 (6.4 %)	<0.001
Postpartum hemorrhage with delivery[c]	28 (29.8 %)	11 (25.0 %)	0.42

[a]Data are median with [interquartile range] or n (%), unless otherwise noted. [b]Other race was either Native Hawaiian or Other Pacific Islander, or American Indian or Alaska Native. [c]For secondary postpartum hemorrhage, the proportion that had a primary postpartum hemorrhage with their delivery. For individuals with a primary postpartum hemorrhage the proportion that reported having a postpartum hemorrhage with a previous delivery (n = 44). BMI, body mass index; EGA, estimated gestational age.

presentation. Documented blood loss in individuals with secondary postpartum hemorrhage was lower than matched controls with primary postpartum hemorrhage, 269 vs. 1,445 mL, respectively (Table 2). Although the proportion of individuals with a secondary postpartum hemorrhage that received a uterotonic, the total number of uterotonics utilized, or placement of a Bakri balloon was similar to individuals with a primary postpartum hemorrhage, there was a larger number of unexpected procedures for bleeding in patients with a secondary postpartum hemorrhage with the most frequent one being performance of a dilation and curettage. Greater than 90 % of individuals with a secondary postpartum hemorrhage were treated with a dilation and curettage for the diagnosis of secondary postpartum hemorrhage. More individuals received a blood transfusion with a primary postpartum hemorrhage when compared to those with a secondary postpartum hemorrhage. Yet the rates of receiving four units or greater of packed red blood cells were similar between the primary and secondary postpartum hemorrhage cohorts.

Table 2: Hemorrhage interventions and outcomes.

Interventions and outcomes	Secondary postpartum hemorrhage	Primary postpartum hemorrhage	p-Value
	n=94	n=94	
Proportion with composite of hemorrhage-related maternal morbidity[a]	90 (95.7 %)	50 (53.2 %)	<0.001
Components of composite outcome			
Maternal death	0 %	0 %	
Hysterectomy	2 (2.1 %)	2 (2.1 %)	1.0
ICU Admission	5 (5.3 %)	9 (9.6 %)	0.39
Blood transfusion	25 (26.6 %)	38 (40.4 %)	0.04
Unexpected procedure for bleeding[b]	86 (91.5 %)	30 (31.9 %)	<0.001
Dilation & curettage	86 (91.5 %)	7 (7.4 %)	<0.001
Bakri placement	23 (24.5 %)	24 (25.5 %)	1.0
Laparotomy	2 (2.1 %)	1 (1.1 %)	1.0
B-lynch procedure	0 %	4 (4.3 %)	
Uterine artery ligation	0 %	3 (3.2 %)	
Hypogastric artery ligation	0 %	0 %	
Secondary outcomes			
Total blood loss (ml)	269 [100–900]	1,445 [1,180–1,805]	<0.001
Any uterotonic use	62 (66.0 %)	69 (73.4 %)	0.32
Total dose of uterotonic	1 [0–2]	1 [0–2]	0.94
≥ 4 Units pRBCs	5 (5.3 %)	7 (7.4 %)	0.75
Coagulopathy	3 (3.2 %)	3 (3.2 %)	1.0
Length of stay (days)	2.0 [1.0–3.0]	3.0 [3.0–4.0]	<0.001

Data are median with [interquartile range] or n (%) unless otherwise noted. pRBCs, packed red blood cells; ICU, intensive care unit. [a]Composite hemorrhage-related maternal morbidity – included maternal death, hysterectomy, intensive care unit admission, blood transfusion, or unanticipated procedures to treat postpartum bleeding. The primary outcome was a count per item but was only counted as one item if there were more than one hemorrhage related morbidity event or procedure per delivery. [b]Includes dilation & curettage, Bakri balloon placement, laparotomy, B-Lynch stitch placement, uterine artery ligation, and hypogastric artery ligation.

In univariate analysis, the primary outcome of composite hemorrhage-related maternal morbidity was greater in individuals with secondary postpartum hemorrhage 95.7 % [90/94] vs. 53.2 % [50/94] in primary postpartum hemorrhage, $p < 0.001$. Individuals with a secondary postpartum hemorrhage had a 19.8 (95 % CI 6.7 to 58.3) greater odds of having the composite hemorrhage-related maternal morbidity than those with a primary postpartum hemorrhage. Logistic regression was performed to calculate adjusted odds ratios and 95 % CI for secondary postpartum hemorrhage compared to primary postpartum hemorrhage, while adjusting for the same clinical variables. After adjusting for potential confounders (age, BMI, ethnicity, gestational age at delivery, multiple gestation, mode of delivery, and the presence of manual delivery of the placenta), the adjusted odds ratio (OR) 16.4, 95 % CI 4.9 to 55.3, remained increased. A backward stepwise approach was then utilized for confounding elimination for any variable with a $p > 0.1$ with estimated gestational age at delivery and vaginal delivery remaining, adjusted OR 14.0, 95 % CI 4.6 to 42.2 (Supplementary Material, Appendix 2). Due to most individuals with secondary postpartum hemorrhage having an unexpected dilation and curettage, a post hoc sensitivity analysis removing the criteria of dilation and curettage from the composite hemorrhage-related maternal morbidity was reanalyzed for both groups. Individuals in the secondary postpartum hemorrhage group had a lower odds of the composite hemorrhage-related maternal morbidity 35.1 % (33/94) when compared to the primary postpartum hemorrhage 52.1 % (49/94), OR 0.50, 95 % CI 0.28 to 0.89. Logistic regression assessment for the same potential confounders as the primary analysis demonstrated an adjusted OR 0.47, 95 % CI 0.26 to 0.85.

Of individuals with a secondary postpartum hemorrhage, 86 underwent a dilation and curettage (with one proceeding to a hysterectomy), and two total underwent a hysterectomy. In individuals with a primary postpartum hemorrhage, seven underwent a dilation and curettage (with none proceeding to hysterectomy), and two total underwent a hysterectomy. In individuals with a secondary postpartum hemorrhage who underwent a dilation and curettage only (n=84), the two most frequent histologic diagnoses were retained placenta 45.2 % and subinvolution 20.2 % (Table 3). In a subgroup analysis, the 20 individuals that underwent a manual extraction of the placenta in their delivery which preceded the admission for secondary

Table 3: Pathology diagnosis from tissue specimens.

Dilation & curettage	Secondary postpartum hemorrhage n=84[a]	Primary postpartum hemorrhage n=7
No tissue obtained	None	6 (85.7 %)
Normal tissue (endometrium)	6 (7.1 %)	1 (14.3 %)
Infection	8 (9.5 %)	None
Placenta accreta spectrum	15 (17.9 %)	None
Subinvolution	17 (20.2 %)	None
Retained placenta	38 (45.2 %)	None
Hysterectomy	**n=3**	**n=2**
No pathologic abnormalities (atony)	None	1 (50.0 %)
Infection	None	None
Placenta accreta spectrum	1 (33.3 %)	1 (50.0 %)
Subinvolution	1 (33.3 %)	None
Retained placenta	1 (33.3 %)	None[a]

[a]Data are n (%). For tissue obtained from dilation & curettage, if the histology noted a microscopic or focal placenta accreta, the specimen was assigned to the category of placental accreta. If histology noted both subinvolution and any placental fragments, the case was assigned to the category of retained placenta alone. aIndividuals that underwent a dilation & curettage only. Two individuals that underwent a dilation & curettage proceeded to hysterectomy.

postpartum hemorrhage was performed. Of these 20 individuals, 60 % (12/20) had a bedside ultrasound evaluating the endometrial cavity after manual placental extraction. Subsequently, 19 had a dilation and curettage with the secondary postpartum hemorrhage and of these 78.9 % (15/19) had retained placenta and 21.1 % (4/19) had placenta accreta on histology. In patients with a primary postpartum hemorrhage tissue was not obtained at the time of dilation and curettage in most individuals 85.7 % (6/7) and the individual that tissue was obtained noted normal endometrium.

Discussion

The results of this study suggest that pregnant individuals admitted with secondary postpartum hemorrhage have a greater composite hemorrhage-related maternal morbidity with an increased rate of treatment by dilation and curettage when compared to individuals with a primary postpartum hemorrhage. Yet, similar rates of uterotonic administration, placement of a Bakri balloon, and performance of a hysterectomy occur, with a lower rate of blood transfusion.

Secondary postpartum hemorrhage is rare, with studies over the past 55 years reporting a range of 0.20–1.6 % of deliveries [10, 16]. Most studies are descriptive without a comparison group. Three studies compared individuals with secondary postpartum hemorrhage to their general obstetric populations without a secondary postpartum hemorrhage [11, 12, 22]. Individuals with a secondary postpartum hemorrhage experienced a high degree of primary postpartum hemorrhage in their delivery (range 19.7–64.0 %) with a greater rate of manual removal of the placenta (range 6–24 %) [11, 12, 22]. In the current study, nearly 30 % of individuals with a secondary postpartum hemorrhage experienced a primary postpartum hemorrhage with their delivery; however, this was similar to matched control subjects that had a primary postpartum hemorrhage and reported a history of postpartum hemorrhage in a prior delivery. These similar rates may be attributed to our use of a control group being individuals with a primary postpartum hemorrhage compared to prior studies that compared to the general obstetric population. We did observe an increased rate of manual placental removal (21.3 %) at the delivery in individuals with a secondary vs. primary postpartum hemorrhage. Manual removal of the placenta may result in a part of the placenta remaining in the uterus resulting in retained placenta. Individuals that had a manual extraction of the placenta and a subsequent dilation and curettage in the present analysis, three-fourths had retained placenta confirmed by histology, despite over half having a bedside ultrasound at the time of manual placental extraction to confirm placental removal. Although the rate of estimated blood loss in individuals with secondary postpartum hemorrhage was less, one must interpret this cautiously. The estimated blood loss for individuals with a primary postpartum hemorrhage included blood loss with the delivery. Given that a delayed postpartum hemorrhage begins outside the clinical environment, blood loss may be underestimated. The proportion of individuals receiving a blood transfusion with a secondary postpartum hemorrhage was lower when compared to those with a primary postpartum hemorrhage.

In the current study, almost all individuals with a secondary postpartum hemorrhage had some component of the composite hemorrhage-related maternal morbidity. The specific morbidity driving the difference between the groups was dilation and curettage in the secondary postpartum hemorrhage group. The sensitivity analysis removing this indication from the composite outcome demonstrated a lower maternal-hemorrhage morbidity when compared to a primary postpartum hemorrhage. With nearly 94 % of individuals who presented with a secondary postpartum hemorrhage undergoing a pelvic ultrasound, what influence this may have on treatment interventions is unclear. Dependent upon which ultrasound characteristic one uses as the best predictor of retained placenta (e.g., presence of an

echogenic mass, thickened endometrial lining, or color Doppler imagining) can modify the sensitivity and specificity for the diagnosis [23]. Clinical signs, symptoms, and ultrasound findings may be associated with a low sensitivity for determining whether postpartum hemorrhage is due to retained products of conception or uterine distension from blood products [24]. Dilation and curettage has been suggested as an efficient way to evacuate the uterus and control hemorrhage [24]. Yet debate exist if conservative medical treatment (e.g., antibiotics and uterotonics) may be alternative options for managing select individuals with secondary postpartum hemorrhage [9, 11, 15, 16, 25].

Strengths and limitations

Strengths of the current analysis is it compares contemporary management methods of individuals presenting with secondary postpartum hemorrhage in the context of outcomes associated with individuals with a primary postpartum hemorrhage. Cases and controls were matched in temporality to allow similar interventions for postpartum hemorrhage to be utilized and compared. This will not only provide information for healthcare professionals to anticipate the more common hemorrhage-related interventions and sequelae but to counsel patients regarding the morbidities associated with a secondary postpartum hemorrhage.

However, our study is not without limitations. This is a single-center study at a tertiary academic center whose patients may not be generalizable to many institutions nationwide. Rates of secondary postpartum hemorrhage may be underrepresented, as there is no way to capture patients with delayed bleeding who present to other settings. In addition, how clinicians define “excessive bleeding” when assessing secondary postpartum hemorrhage may be subject to observer bias. Outcome variables identified retrospectively from an administrative database (e.g., ICD-10 codes) are constrained by the accuracy of the coded data, with potential risks of under-ascertainment and misclassification bias. In addition, how clinicians define “excessive bleeding” when assessing secondary postpartum hemorrhage may be subject to observer bias. Currently, no standardized guidelines are utilized in obstetrics and gynecology for the ultrasound diagnosis of retained placenta and it is left to the clinician’s discretion as to the best treatment intervention. While subinvolution of the placental site is an underrecognized etiology of secondary postpartum hemorrhage, this can only be diagnosed by histology analysis, and radiology imaging of this condition has a low predictive value. While using a composite outcome is helpful for rare events [26], the composite hemorrhage-related maternal morbidity for secondary postpartum hemorrhage was driven by the performance of a dilation and curettage and may not be the best outcome estimate for this clinical condition. Yet, in the present analysis, we defined each component of the composite outcome consistently throughout the investigation as defined initially [17], analyzed the prespecified composite, and listed the results for all components. The wide confidence interval noted in the adjusted odds ratio implies a lack of precision and may have been influenced by the small sample size. However, the trend was above the null and is present in both the observed analysis and when adjusted for potential confounding variables. Finally, the sample sizes within the individual subgroups of the composite outcome may be insufficient to exclude the possibility of a type II error in detecting small differences in the measured outcome variables.

Conclusions

Increased composite maternal hemorrhage outcome occurs in individuals with secondary compared to primary postpartum hemorrhage. The association of the utilization of dilation and curettage with secondary postpartum hemorrhage suggest a different paradigm for management when contrasted with primary postpartum hemorrhage. While a dilation and curettage may be a more utilized treatment for secondary postpartum hemorrhage, an unanticipated surgical procedure after a delivery should be viewed as a morbid event which has the potential to disrupt breastfeeding, infant bonding, and affect maternal mental health. The study’s current findings may assist in assessing secondary postpartum hemorrhage risk when high-risk conditions are identified in the transition to postpartum care in a pregnancy. Due to the potential of clinician bias for treatment interventions, future prospective trials comparing different treatment modalities for secondary postpartum hemorrhage are desperately needed.

Research ethics: IRB Approval 4/2/2021 by Baylor College of Medicine (Protocol H-48600).
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Appendix 1: Diagnostic and procedure codes used to identify cases of secondary postpartum hemorrhage.

Code description	Code type	Codes
Delayed and secondary postpartum hemorrhage	ICD-10-CM	O72.2
Postpartum hemorrhage	ICD-10-CM	O.72.0
		O72.1
		O72.3
Other immediate postpartum hemorrhage	ICD-10-CM	O72
Hysterectomy with cesarean delivery	CPT	59,525
Postpartum hysterectomy following vaginal delivery	CPT	58,150
Dilation and curettage procedure	CPT	58,120

ICD-10-CM, international classification of disease, 10th revision, clinical modification; CPT, current procedural terminology.

Appendix 2: Logistic regression analysis for composite maternal hemorrhage outcome for secondary postpartum hemorrhage compared to primary postpartum hemorrhage adjusting for potential confounding variables.

	Secondary PPH n (%) or median IQR	Primary PPH n (%) or median IQR	Unadjusted or (95 % CI)	Adjusted Model I[a] or (95 % CI)	Adjusted Model II[b] or (95 % CI)
Variable					
Age, years	32.0 (29.0–35.0)	28.0 (25.0–33.0)	1.04 (0.97–1.11)	0.97 (0.90–1.05)	
BMI, kg/m^2	29.5 (26.1–35.7)	33.5 (29.1–40.2)	0.96 (0.92–1.00)	0.96 (0.91–1.01)	
Hispanic ethnicity	30 (31.9 %)	47 (50.0 %)	0.47 (0.26–0.85)	0.78 (0.31–1.96)	
EGA @ delivery (weeks)	38.0 (36.6–39.6)	39.1 (37.3–40.0)	0.89 (0.73–1.09)	0.76 (0.59–0.98)	0.80 (0.64–1.12)
Multiple gestation	9 (9.6 %)	4 (4.3 %)	1.72 (0.33–9.09)	2.44 (0.39–14.29)	
Vaginal delivery	59 (62.8 %)	35 (37.2 %)	3.40 (1.48–7.80)	4.24 (1.63–11.07)	4.33 (1.78–10.54)
Manual placenta removal	20 (21.3 %)	6 (6.4 %)	1.40 (0.33–5.87)	1.37 (0.26–7.14)	
Outcome					
Composite outcome	90 (95.7 %)	50 (53.2 %)	19.8 (6.7–58.3)	16.4 (4.9–55.3)	14.0 (4.6–42.2)

BMI, body mass index; EGA, estimated gestational age. [a]Model I: Logistic regression analysis adjusting for all univariate variables with a $p \leq 0.1$ (age, BMI, ethnicity, gestational age at delivery, multiple gestation, mode of delivery, and the presence of manual delivery of the placenta). [b]Model II: Logistic regression analysis using a backward stepwise approach for confounding elimination for any variable with a $p > 0.1$ (estimated gestational age at delivery and vaginal delivery).

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