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Full Length Research Paper

The use of a linear cutting stapler for hysterotomy during cesarean hysterectomy for patients with placenta accreta spectrum

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Abstract

During a cesarean hysterectomy surgery for placenta accreta spectrum, two procedures contributed to the total surgical blood loss, the uterine hysterotomy portion for fetal delivery and the hysterectomy portion. Previous studies had aimed at decreasing blood loss with techniques targeting the hysterectomy portion. We aimed to evaluate the impact of performing hysterotomy utilizing a linear cutting stapler in minimizing blood loss during cesarean hysterectomy compared to the classical hysterotomy technique with scalpel in patients with suspected placenta accreta spectrum disorders. This was a single-center retrospective cohort study including a total of 95 patients undergoing cesarean hysterectomies over a period of 8 year between January 2014 and January 2022. 31 patients in the intervention group underwent hysterotomy performed with a linear cutting stapler. 64 patients in the control group underwent the classical hysterotomy performed with scalpel. The primary outcomes were quantitative total blood loss, units of red blood cell transfusion, length of postoperative stay, and intensive care unit admission. Compared to the classical hysterotomy group, the linear stapler hysterotomy group was associated with a significant reduction in surgical blood loss (1000mL vs 2553mL (*p*<0.001)), units of red blood cell transfused (1 vs 3 units (*p*<0.001)), and postoperative length of stay (3 vs 4 days (*p*<0.001)). The rates of surgical blood loss of >2000ml in the linear stapler hysterotomy group was 22.6% vs 48.4% (adjusted odd ratio 0.23 [0.06-0.79]). The rate of transfusion of >4unit of *p*RBC in the linear stapler hysterotomy group was 16.1% vs 48.4% (adjusted odd ratio 0.26 [0.07-0.97]). The method of performing hysterotomy utilizing a linear cutting stapler was associated with a significant reduction in surgical blood loss, units of red blood cell transfusions, and postoperative length of stay compared to the classical hysterotomy method via scalpel in patients undergoing cesarean hysterectomy for suspected placenta accreta spectrum.

Keywords: Placenta accreta, placental disorders, cesarean hysterectomy, linear stapler, hysterectomy, blood loss, blood transfusion.

INTRODUCTION

Placenta accreta spectrum (PAS) is associated with severe maternal morbidities and is estimated to occur in 0.3% of patients with one prior cesarean delivery and up to 67% in women with placenta previa and a history of four or more prior cesarean deliveries (Belfort, 2010; Marshall *et al.*, 2011). PAS occurs when there are abnormal trophoblast adherence to the myometrium, instead of the decidua; this condition includes a range of pathologic adherence of the placenta, including placenta accreta, placenta increta, and placenta percreta (Silver & Barbour, 2015; Matsuzaki *et al.*, 2021). Placenta accreta occurred more commonly than percreta and increta, however, the latter two pathologies were associated with markedly increased risks of surgical mortality (Matsuzaki *et al.*, 2021). The incidence of PAS disorder was expected to

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increase due to the rise in cesarean delivery rates over the last two decades (Jauniaux *et al.*, 2018). Definitive management for PAS disorder is cesarean hysterectomy, which is associated with significant maternal morbidity and mortality. The median blood loss reported for this procedure was between 2-4L, and up to 95% of patients required blood transfusion (Eller *et al.*, 2009; Hoffman *et al.*, 2010; Stotler *et al.*, 2011; Wright *et al.*, 2011; Shamshirsaz *et al.*, 2015). Studies examining blood product utilization during cesarean hysterectomies had reported that the median units of transfused packed red blood cells (*p*RBC) was 3.5-4.5, and up to 40% of the cases could require large-volume blood transfusions (>10L) (Wright *et al.*, 2011; Allen *et al.*, 2018). Antenatal diagnosis of PAS, delivery at a tertiary maternal care facility, and multidisciplinary expertise had been shown to significantly improve maternal outcomes, yet the risk of severe hemorrhage remains a concern (Shamshirsaz *et al.*, 2015).

Previous studies demonstrated a decrease in surgical blood loss through methods including delayed hysterectomy after cesarean delivery (Zuckerwise *et al.*, 2020), dissection of the bladder flap down to the level of the cervix prior to the hysterotomy (Saha *et al.*, 2018), multiple-staged procedure (Angstmann *et al.*, 2010), and perioperative balloon occlusion of the distal aorta (Ioffe *et al.*, 2021). Other techniques utilizing endovascular balloon occlusion of the internal iliac artery demonstrated mixed results on surgical blood loss (Bodner *et al.*, 2006; Salim *et al.*, 2015; Gulino *et al.*, 2018; Shahin & Pang, 2018; Chen *et al.*, 2019) and were associated with risk of thrombotic events (Nieto-Calvache *et al.*, 2020; Ioffe *et al.*, 2021). It is important to note that most of the previously proposed techniques aimed to reduce blood loss with the hysterectomy portion of the cesarean hysterectomy and few studies had addressed the hysterotomy technique associated with the fetal delivery portion of the case.

A common current practice for fetal delivery is performing a classical hysterotomy incision with scalpel, which could result in up to 800mL of blood loss even before the hysterectomy portion was started (Belfort *et al.*, 2017). In a case series of three patients, Belford *et al.* previously described a method using the linear cutting stapler to create the hysterotomy which reduced the blood loss to less than 20mL (Belfort *et al.*, 2017). The linear cutting stapler is a commonly used device in General Surgery. In the obstetrical application, a row of staples are deployed along the hysterotomy edge, achieving hemostasis throughout the fetal delivery and the hysterectomy portion. Limited data exists in evaluating the clinical benefit of this technique in cesarean hysterectomy for PAS. A recent single-center study reported the benefit of a combination of utilizing the linear stapler hysterotomy technique and vessel sealing device during the hysterectomy, which demonstrated decreased blood loss (Cojocaru *et al.*, 2020). However, it was uncertain whether the reported benefit is primarily attributed to either the linear cutter utilization technique alone or to the combination of both the stapler and vessel sealant devices.

In this study, we aimed to evaluate the impact of using the linear cutting stapler to create the hysterotomy during cesarean hysterectomy on surgical outcomes and reduction in blood loss in patients with PAS. We hypothesized that the linear cutting stapler hysterotomy technique could reduce the total surgical blood loss and transfusion rates compared to the cases utilizing the classical hysterotomy method during cesarean hysterectomy for patients with PAS.

MATERIALS AND METHODS

This was a single-center retrospective study in a tertiary referral academic institution. This study was approved by the Institutional Review Board (IRB# 520052). Cesarean hysterectomies performed between January 2014 and January 2022 were reviewed for inclusion. Prior to 2014, a different medical record system was used for documentation which limits accessibility. Cases were included in the analysis if PAS was suspected based on antenatal ultrasound evaluations and if the surgeries were performed on a scheduled basis. Cases were excluded if PAS was not suspected at time of delivery or if cesarean hysterectomy was performed emergently for maternal hemorrhage or non-reassuring fetal heart tracing. The final analysis included 95 cases. The control included cases undergoing the classical hysterotomy approach utilizing scalpel.

The intervention of interest was the linear stapler hysterotomy entry technique first described by Belfort *et al.* (2017). First, the superior edge of the placenta is mapped by ultrasound in relation to the uterus and abdominal wall prior to the start of surgery. A midline abdominal incision is created to allow access up to the uterine fundus. Four full thickness 0-Vicryl on CT sutures are placed in the uterine corpus in a box configuration superior to the placental edge to create an avascular window for uterine entry. Diathermy is then used to create a small hemostatic uterine entry within the window with care to avoid fetal injury. A 75mm linear cutting stapler (Ethicon Proximate Linear Cutter, Somerville, New Jersey) is inserted with direct palpation to confirm no fetal injury, then used to extend the hysterotomy in the cephalad direction with up to 3-4 reloads to create a hemostatic hysterotomy large enough to accommodate the delivery of the fetus (Figure 1, Video link below). Knowledge of placental location is paramount to avoid placental disruption and hemorrhage during delivery. Following the delivery of the fetus, the placenta is left *in situ* and the hysterotomy is reapproximated with up to 8 sharp towel clamps for traction and continued hemostasis. The hysterectomy portion was subsequently performed in similar manner in all cases. The linear stapler hysterotomy technique was introduced at our institution in 2019. It was performed by one Maternal-fetal Medicine (MFM) faculty member. In cases where the faculty member was not available, other faculty members performed the classical hysterotomy technique with scalpel for fetal delivery in the same fashion. In both groups, Gynecologic Oncology and Obstetric faculty members jointly performed the hysterectomy portion of all cases. A vessel sealing device was routinely used for hysterectomy in all cases since 2014 to ligate the upper pedicles and assist with the remainder of the surgical procedure. Major pedicles are suture ligated.

Surgical outcomes of interest included total quantitative blood loss (QBL), units of pack red blood cells (*p*RBC) transfused during intraoperative and postoperative periods, postoperative length of stay (LOS), and surgical intensive care unit (ICU) admission. The QBL was determined based on the suction canister volume, laparotomy sponge count, and

clinical assessment of any other unaccounted blood loss. QBL was assessed as a linear variable and was further subcategorized as blood loss of more than 2000mL. Red blood cell transfusion was assessed in the number of units transfused, with notation made in cases requiring greater than 4 units. Surgical outcomes were compared between cesarean hysterectomy cases performed with the reduced blood hysterotomy method and cesarean hysterectomy cases performed with the traditional classical hysterotomy.

Patient demographic data and surgical outcomes were compared using univariate statistical methods. Linear variables were tested for normal distribution using the Shapiro-Wilk test. Normally distributed variables were compared between groups using the t-test, otherwise the Kruskal-Wallis test was used. Categorical variables were compared between the two groups using the chi-square test. Statistical significance was defined as *p*-value <0.05.

Additionally, we started using resuscitative endovascular balloon occlusion of the aorta (REBOA) in severe PAS cases since 2019, based on ultrasonographical signs suggesting the severity of PAS. In a previously published report, we had demonstrated an association between REBOA and a decrease in surgical blood loss (Ioffe *et al.*, 2021). Therefore, logistic regression analyses were performed to adjust for the effects of REBOA, as well as the severity of disease based on final pathological report and numbers of prior Cesarean deliveries. Statistical analysis was performed using the Stata 17 (College Station, TX).

RESULTS

Between January 2014 and January 2022, there were 120 cesarean hysterectomies performed for PAS. In this cohort, 8 patients were excluded for undiagnosed accreta and 17 patients were excluded for emergent deliveries (12 cases were performed due to bleeding and 5 cases were due to non-reassuring fetal heart tracing). After all exclusions, 95 patients remained eligible for further analysis. Of these cases, classical hysterotomy with scalpel technique was performed in 64 patients and linear stapler hysterotomy technique was performed in 31 patients (Figure 2).

Demographic information including maternal age, BMI, race/ethnicity, and insurance type were similar between classical hysterotomy and linear stapler hysterotomy groups (Table 1). Both groups had similar severity of PAS disorder, specifically placenta percreta. The patients in the linear stapler hysterotomy, compared to the patients in the classical hysterotomy group, delivered at 34 weeks vs 35 weeks (p=0.01), and had a history of 2 vs 3 prior cesarean deliveries (p=0.046), respectively. Since 2019, we also started to perform preoperative assessment for the use of REBOA in cesarean hysterectomy based on the severity of PAS disorder suggested by antenatal ultrasonography, and had an increase in REBOA use in the linear stapler hysterotomy group.

The median total surgical blood loss using the linear stapler hysterotomy technique was 1000mL vs 2553mL in the classical hysterotomy method, p<0.001 (Table 2). Compared with the classical hysterotomy group, the median units of *p*RBC transfused in the linear stapler hysterotomy group was 1 unit vs 3 units, p<0.001, and postoperative length of stay was 3 days vs 4 days, p<0.001. The rate of surgical blood loss of >2000mL in the linear stapler hysterotomy group was 22.6% vs 48.4% in the classical hysterotomy group, p<0.02, adjusted odds ratio (aOR) 0.23 [0.06-0.79]. The rate of transfusion of >4units of *p*RBC in the linear stapler hysterotomy group was 16.1% vs 48.4% in the classical hysterotomy group (p<0.002, aOR 0.26 [0.07-0.97]). The rate of cases not requiring blood transfusion in the linear stapler hysterotomy group was 45.2% vs 20.3% in the classical hysterotomy group (p<0.02, aOR3.02 [1.05-8.73]). After adjusting for the effects of REBOA on blood loss, numbers of prior cesarean delivery, and PAS severity, the odds ratios of QBL >2000mL, transfusing more than 4 units of *p*RBC, and not requiring transfusion remained statistically significant (Table 3). The risks of ICU admission was not significantly different in both groups. No reported bowel, bladder, or fetal injuries were caused by the stapler device in the linear stapler hysterotomy group. Furthermore, there were no maternal deaths in both groups.

DISCUSSION

In this retrospective cohort study examining an 8-year study period, we demonstrated that the linear stapler hysterotomy technique significantly reduced blood loss, *p*RBC transfusion, and postoperative stay compared to the classical hysterotomy with scalpel method. Patients undergoing the linear stapler hysterotomy method during the cesarean hysterectomy were almost 77% less likely to have EBL >2000ml, 74% less likely to require more than 4 units of *p*RBC.

When the cesarean hysterectomy procedure is grossly examined as a whole, it can be subdivided into two subparts, each contributing to the total surgical blood loss, the hysterotomy portion and the hysterectomy portion. Previous studies have aimed at decreasing blood loss with techniques targeting the hysterectomy portion as described above in the introduction section. Another group reported a technique for decreasing blood loss, which utilized fetal surgery entry technique for hysterotomy, followed by leaving placenta *in situ* and performing delayed hysterectomy in 4-6 weeks (Zuckerwise *et al.*, 2020), thus requiring reoperation and rehospitalization. The use of endovascular balloon occlusion in the internal iliac artery demonstrated mixed results with some studies demonstrated a reduction in blood loss (Dai *et al.*, 2018; Gulino *et al.*, 2018; Shahin & Pang, 2018; McGinnis *et al.*, 2019), while others showed no difference of blood loss in the intervention group (Bodner *et al.*, 2006; Salim *et al.*, 2015; Chen *et al.*, 2019), all carrying the risk of thrombotic events (Nieto-Calvache *et al.*, 2020). Few studies have investigated the effect of hysterotomy techniques on blood loss reduction. Prior to the implementation of this linear hysterotomy technique, the average blood loss in a cesarean hysterectomy at our institution was consistent with the reported average range in the literature (Eller *et al.*, 2009; Hoffman *et al.*, 2010; Wright *et al.*, 2011; Shamshirsaz *et al.*, 2015). In our institution, this technique reduced the median overall procedural blood loss to 1000mL, not much more than the average blood loss for a cesarean section delivery of 800-1000mL (Stafford *et al.*, 2008; Maswime & Buchmann, 2017). Our study is one of the firsts to demonstrate the benefits of the

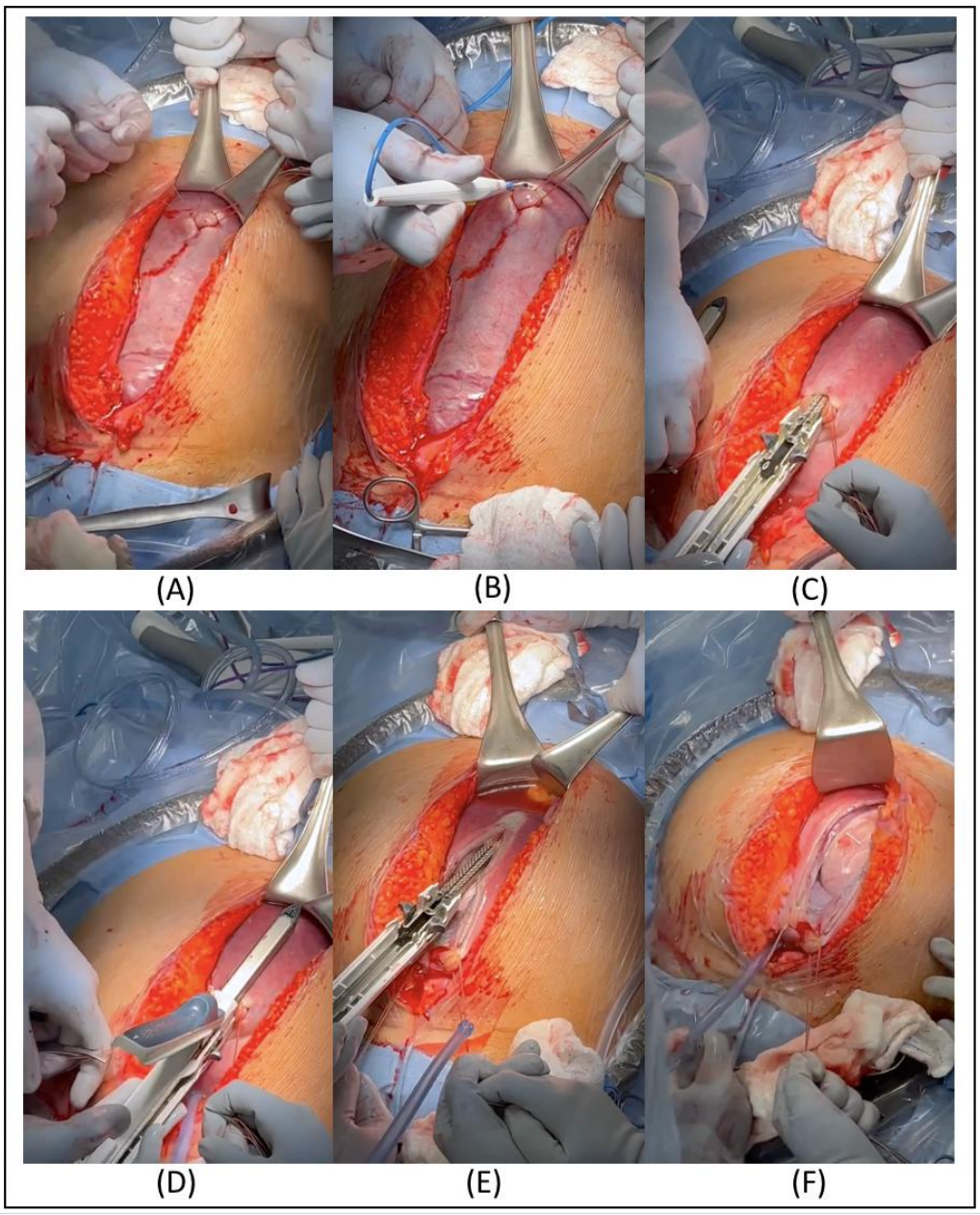

Figure 1: Performing hysterotomy with linear stapler for fetal delivery.
(A) Creation of an avascular window for uterine entry
(B) Diathermy was used to create a small hemostatic uterine entry
(C-D) The bottom and the top blade of the linear cutting stapler were applied
(E) Creation of hysterotomy after 2 stapler reloads with hemostatic edges
(F) Creation of hysterotomy after 3 stapler reloads, large enough to accommodate fetal delivery
Video Link: https://youtu.be/WcQNvD78JR8.

linear stapler hysterotomy technique in surgical outcomes and proposes that this technique could be utilized in tandem with the preexisting surgical protocol that a multidisciplinary PAS institution already has. The benefits of a multidisciplinary expertise on improved maternal outcomes have been previously established, thus we emphasize the importance of a multidisciplinary approach to the antepartum and surgical management for patients with PAS (Silver *et al.*, 2015; Shamshirsaz *et al.*, 2018). We acknowledge the important role of a multidisciplinary surgical team composition and standardized surgical approaches at our institution as well as the experienced supporting nursing and surgical technician staff that allowed efficient and proficient surgical operations. All were factors that had been shown in previous studies to reduce blood loss over time. We also recognized that repetition and experience is a known factor for improvement in any surgical procedure, thus improving surgical skills over time could potentially contribute to the overall outcomes.

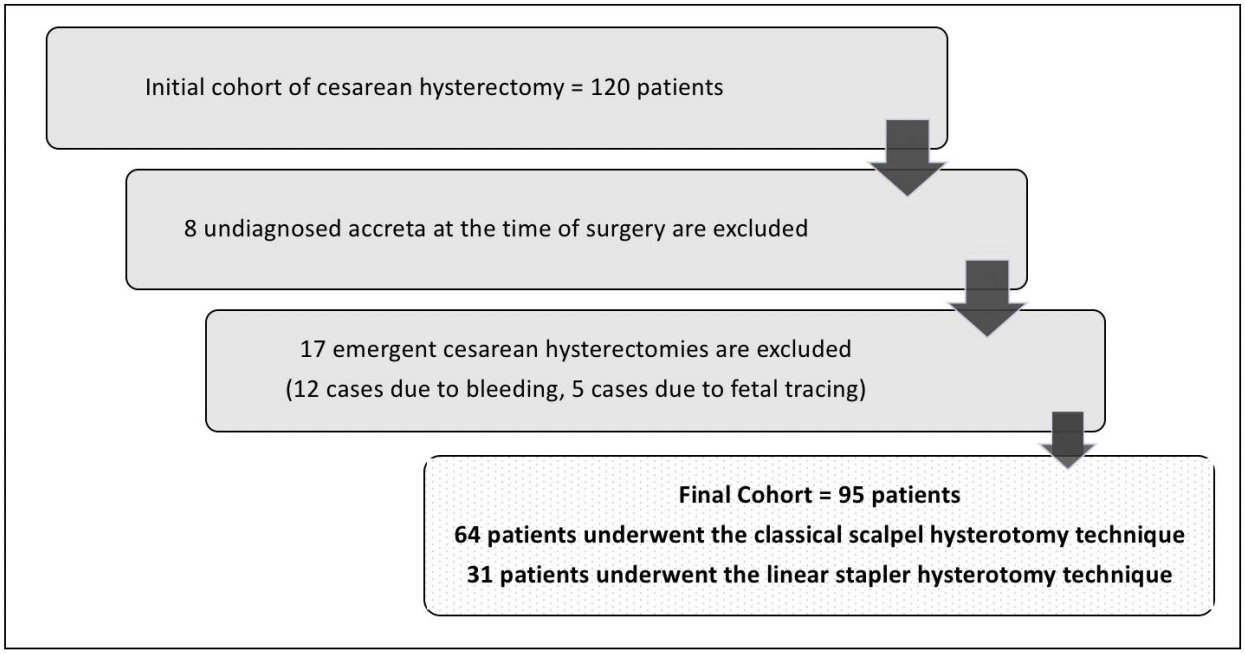

Figure 2: Cohort selection.

Table 1: Demographics of cohort.

	Classical Scalpel Hysterotomy	Linear Stapler Hysterotomy	*p* value
n	**64**	**31**	
Maternal age	32.1±5.5	33.0±4.9	*0.44*
Gestational age at delivery	35 [34, 36]	34 [33, 35]	*0.01*
Parity	3 [2, 4]	3 [2, 4]	*0.22*
Number of cesarean delivery	3 [2, 4]	2 [1, 3]	*0.046*
BMI	34.0±8.3	34.0±7.6	*0.99*
Race/Ethnicity			
Hispanic	39 (66.1)	35 (63.6)	
Black	8 (12.5)	7 (22.6)	*0.36*
White	11 (17.2)	6 (19.4)	
Asian	4 (6.3)	0	
Other	2 (3.1)	0	
Private insurance	51 (79.7)	25 (80.7)	*0.91*
Percreta	25 (39.1)	18 (58.1)	*0.08*
REBOA use	9 (14.1)	13 (41.9)	*0.003*
Chronic hypertension	5 (7.8)	3 (9.7)	*0.76*
Pregestational diabetes	5 (7.8)	3 (9.7)	*0.76*

Results are presented as mean±SD, median [IQR], or n(%).

We observed several benefits of the linear stapler hysterotomy technique based on our experience in the operating room. The reloadable linear stapler, which laid down a row of 3D staples, offered an advantage of a rapidly achieving hemostatic hysterotomy edges during the delivery of the fetus and throughout the hysterectomy portion, allowing minimalization of continuous blood loss from the hysterotomy during the case. The hemostasis of the hysterotomy that was afforded by the stapler allowed the team to carefully and efficiently proceed with the bladder dissection and securing

Table 2: Surgical outcomes associated with the use of linear cutting stapler.

	Classical Hysterotomy	Linear Stapler Hysterotomy	*p*-value
Surgical blood loss (ml)	2553 [1050, 3100]	1000 [500, 1600]	*0.001*
Unit of *p*RBC transfusion	3 [1, 6]	1 [0, 2]	*0.001*
Postop length of stay (days)	4 [3.5, 5]	3 [3, 4]	*0.001*
QBL >2000 mL	31 (48.4)	7 (22.6)	*0.016*
Transfusion of *p*RBC>4 units	31 (48.4)	5 (16.1)	*0.002*
No blood transfusion	13 (20.3)	14 (45.2)	*0.012*
ICU admission	11 (17.2)	3 (9.7)	*0.33*

Results are presented as median [IQR], or n(%).

Table 3: Regression analysis of linear stapler hysterotomy adjusting for potential confounders.

	OR [95% CI][a]	aOR [95% CI][b]
QBL >2000 mL	0.31 [0.12 - 0.82]	0.23 [0.06- 0.79]
Transfusion of *p*RBC>4 units	0.20 [0.07 - 0.60]	0.26 [0.07 - 0.97]
No blood transfusion	3.23 [1.27 - 8.22]	3.02 [1.05–8.73]
ICU admission	0.52 [0.13 - 2.00]	0.47 [0.10 - 2.11]

[a]Data is presented as odd ratio [95% Confidence interval]
[b]Odd ratios are adjusted for REBOA, severity of disease, and number of previous cesarean deliveries.

uterine pedicles in a meticulous manner. We did not need to close the hysterotomy with sutures post-delivery as described by Belfort *et al*. In addition, we further observed that the use of the stapler was low cost and safe with no complications of bowel, bladder, or fetal injuries caused by the device. Therefore, we believe that with proper application of the stapler, the risks for this technique are minimal. Furthermore, more studies had observed the benefits of utilizing the stapler device in surgical management of patients with PAS. In a recent study in which a stapler device was used to perform ligation of vascular and uterine pedicles during hysterectomy, the investigators noted a decrease in operative time (Smith *et al.*, 2022).

The results observed in this study presented another method for performing hysterotomy for fetal delivery via the utilization of a liner stapler instead of the traditional hysterotomy with scalpel. We advocate for the adoption of this technique to perform hemostatic hysterotomy, as the stapler device is low cost and has a well-established safety profile in General Surgery. The stapler hysterotomy technique could be used in tandem with preexisting surgical protocols in other institution to aim at reducing surgical blood loss.

Strengths and Limitations

To our knowledge, since the initial introduction of the linear stapler hysterotomy method in 2017, this study is the one of largest retrospective cohort study to directly demonstrate the benefits of the linear stapler hysterotomy technique in reducing surgical blood loss, using the PubMed and OVID database search including keywords ‘placenta accreta’, ‘staple’, ‘hysterotomy’ and their derivatives. This study was further controlled for confounders through regression models. The device is readily available in most institutions and the described technique is unchallenging to learn. This study is not without limitations. This is a single-center study in a large academic institution with a dedicated multidisciplinary team for PAS, thus the results might not be generalizable to other centers that do not have similar existing infrastructure. While this study is limited to outcomes from a single MFM surgeon, we anticipate future studies to further evaluate the reproducible benefits of this technique when performed by other surgeons.

CONCLUSION

The linear stapler hysterotomy technique for fetal delivery demonstrates a significant reduction in blood loss and blood transfusion during cesarean hysterectomy in patients with PAS. This novel technique presents a safe and low cost surgical approach to target blood loss, which could be used in conjunction with preexisting surgical techniques in other institutions.

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