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Original Research

Efficacy and safety of autologous blood transfusion during cesarean section for placenta previa: a single-center retrospective study

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Abstract

Background: Postpartum hemorrhage is a life-threatening pregnancy complication and we want to evaluate the safety and efficacy of autologous blood transfusion during cesarean section in women with placenta previa to deal with postpartum hemorrhage. **Methods**: We conducted a retrospective study concentrating on all cases of placenta previa using autologous blood recovery during cesarean section in a single-center from August 2016 to July 2018, and then grouped and compared the clinical and patient characteristics. Linear regression analysis was conducted to analyze the linear relationships between estimated blood loss and recovered autologous blood volume, recovered autologous blood volume and transfused autologous blood volume, and transfused autologous blood volume and estimated blood loss. **Results**: In our study, autologous blood recovery technology was used during cesarean section for 294 patients with placenta previa, and a total of 266,660 mL of blood was collected and 134,342 mL of autologous blood was transfused, saving 746 U of red blood cell suspension. Recovered and transfused blood volumes were higher in patients with suspected placenta accreta and resection of the uterus. There were no serious adverse reactions related to autologous blood recovery and transfusion. **Conclusions**: The use of autologous blood transfusion during cesarean section in patients with placenta previa is safe and can save blood resources.

Keywords: autologous blood transfusion; intraoperative cell salvage; cesarean section; placenta previa

1. Introduction

Postpartum hemorrhage is a life-threatening pregnancy complication and is one of the most common causes of maternal death with about 166,000 deaths from obstetric hemorrhage worldwide every year [1]; it is the leading cause of maternal death in China. Common causes of hemorrhage are placental disorders (e.g., placenta previa, placental abruption, placental accreta, and retained placenta), uterine rupture, uterine inertia, birth canal injury, and abnormal blood coagulation [2]. In 2015, China implemented the second-child policy nationwide. This resulted in an increase in the number of pregnant women with advanced age, pregnancies in women with a scarred uterus, pregnancy comorbidities such as placenta accreta, placenta previa, and placental abruption, thus increasing the risk of massive hemorrhage. For postpartum hemorrhage, in addition to hemostatic treatment measures with medication, and surgery, blood volume must be quickly restored. The current allogeneic blood resources in China mainly come from voluntary blood donation, but there has been a severe shortage for a long time. Further, allogeneic blood transfusions may increase the risk of infectious diseases and immune reactions. Intraoperative autologous blood recovery technology can mitigate the problems of shortages, infections and transfusion reactions, and reduce transfusion costs.

Intraoperative cell salvage (IOCS) is the use of blood recovery devices to collect the patient's lost blood during surgery, perform anticoagulation, filtration, and washing, after which it can be transfused back into the patient. The West China Second University Hospital, Sichuan University, is a referral center for critically ill pregnant and postpartum women in Southwest China. As a result of our high quality placental magnetic resonance imaging (MRI) and interventional hemostasis technology, our hospital receives many referrals of high-risk pregnancies including placenta previa, especially those with placenta accreta. In August 2016, we introduced intraoperative obstetric autologous blood recovery technology for use during cesarean section. This study summarizes the case data of autologous blood transfusions during cesarean section for placenta previa in our hospital.

2. Methods

We retrospectively analyzed 294 cases of cesarean section for placenta previa [3] performed with autologous blood recovery at our hospital from August 2016 to July 2018. The study was approved by the Ethics Committee of the West China Second University Hospital, Sichuan University (2017-M-033).

Inclusion criteria: Cases with an intraoperative estimated blood loss of over 1000 mL or greater than 20% of blood volume. Exclusion criteria: Cases in which patients or family members refused the use of IOCS.

The IOCS at our hospital is done using a double-tube recovery method. An ordinary suction tube is used to extract as much of the blood mixed with amniotic fluid as possible. After the fetus is removed and residual amniotic fluid is mopped up, a replacement suction tube with heparin (25,000 U of heparin added to 1000 mL of normal saline) is used to collect the blood in the operating field and filter out the hard-to-remove components with a new vitamin E modified multilayer membrane leukocyte filter (CL-E). If the suction tube with heparin is contaminated by or has sucked up, amniotic fluid, the entire suction tube, centrifuge cup, and blood bag will need to be replaced. When the blood collected in the reservoir reaches 800 mL, which is about a cupful of red blood cells, it will automatically begin the washing and concentrating stage. The hematocrit of the final product will be about 50%–55%. If the collected volume is less than 800 mL, the washing and concentration stage is manually initiated and the hematocrit of the finished product will be less than 50%. The recovered blood is warmed by a thermostat and transfused into the patient.

For this study, we collected the general data of all cases, such as age, pregnancies, parity, gestational weeks, and pregnancy comorbidities and complications. We also collected data on the surgical status and clinical outcomes, such as surgery time, blood loss, autologous blood recovery and transfusion volume, hysterectomy, severe adverse maternal outcomes, and treatment costs. This study grouped and compared the clinical characteristics of autologous blood recovery alone vs. autologous blood recovery and transfusion during surgery, suspected accreta vs. non-suspected accreta before surgery, and resection of uterus vs. retention of uterus. We analyzed the relationships between recovered autologous blood volume and estimated blood loss as well as recovered autologous blood volume and transfused autologous blood volume.

Statistical methods: All variables are expressed as mean $\pm$ standard deviation or frequency (percentage). The Student's *t*-test was used to compare the mean values between groups and the chi-squared test was used to compare the inter-group rates of categorical variables. Linear regression analysis was used to analyze the relationships between recovered autologous blood volume and estimated blood loss as well as recovered autologous blood volume and transfused autologous blood volume. All statistical analyses were performed using SPSS 24.0 software (SPSS Inc., Chicago, IL, USA), and $p < 0.05$ indicated a statistically significant difference.

3. Results

From August 2016 to July 2018, there were 13,076 deliveries in our hospital, including 2017 cases of placenta previa and 448 cases of pernicious placenta previa. IOCS was used with 294 patients and 266,660 mL of blood was collected while 134,342 mL of autologous blood was transfused. The whole blood yielded 1 U of allogeneic red blood cells for each 200 mL, and this contained about 90 mL of pure red blood cells (approximately 45% of HCT). The HCT of autologous blood in our hospital was about 50%. The formula for converting autologous blood into allogeneic blood was: Allogeneic blood (U) = Autologous blood $\times$ 50%/90 mL, which is equivalent to saving 746 U of red blood cell suspension.

Table 1 also shows the analysis of general data of the 294 patients. Table 2 summarizes the surgical method, surgery time, intraoperative blood loss, intraoperative recovered and transfused autologous blood volume, and the postoperative condition of the patients who had undergone cesarean section, and the analyses of the clinical outcomes. The mean intraoperative blood loss (including suction bottle recovery + autologous blood recovery + bed sheet and pad weighing) was 1979 $\pm$ 1451 mL. Patients flow chart was shown in Fig. 1. Allogeneic blood transfusion was needed in 105 cases. There were 67 cases of hysterectomy (22.8%). Table 3 shows a stratified analysis of the cases of autologous blood recovery during cesarean section. After comparing the cases of recovery and transfusion it was noted that 83 of the 294 cases (28.2%) were not transfused. There was no statistical significance between the two groups in age, prepartum BMI, gestational weeks, pregnancies, number of previous curettages, vaginal bleeding in the second and third trimesters of pregnancy, and anterior placenta ($p > 0.05$). There was, however, a statistical significance in parity, the number of previous cesarean sections, prepartum hemoglobin, preoperative suspected placenta accreta, blood loss, and allogeneic blood cost ($p < 0.05$). Table 4 shows a statistical significance in pregnancies, hysterectomy, blood loss, recovered blood volume, transfused blood volume, total hospitalization cost ($p < 0.05$). Table 5 shows the comparison between the cases of resection or retention of the uterus. There was a statistically significant difference between the two groups in parity, number of previous cesarean sections, preoperative hemoglobin, the proportion of placenta accreta, blood loss, recovered and transfused autologous blood volume, and costs ($p < 0.05$).

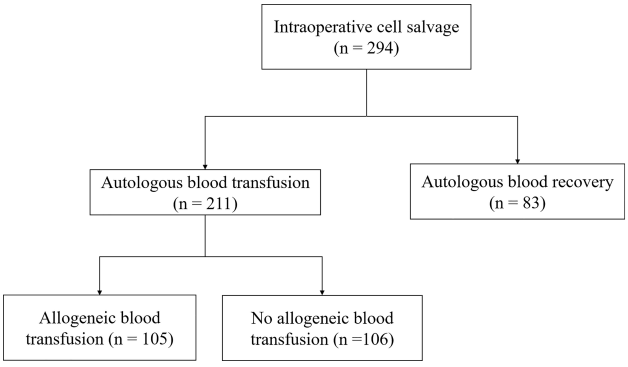

Fig. 1. Flowchart of selection of the patients for the study.

Table 1. General data of autologous blood recovery cases during cesarean section for placenta previa.

General data	N = 294
Age (y)	33.1 ± 4.8
Prepartum BMI	26.4 ± 3.0
Gestational weeks (wks)	35.8 ± 2.7
Pregnancies	4 (2, 9)
Parity	1 (1, 4)
Gestational diabetes mellitus	63 (21.4%)
Hypertension during pregnancy	2 (0.7%)
Twins	7 (2.4%)
Number of previous cesarean sections	
0	26 (8.8%)
1	243 (82.7%)
2	24 (8.2%)
3	1 (0.3%)
Number of previous curettages	
0	44 (15.0%)
1	62 (21.1%)
2	98 (33.3%)
≥3	90 (30.6%)
Prepartum hemoglobin (g/L)	112 ± 14
Vaginal bleeding in the second and third trimesters of pregnancy	82 (27.9%)
Anterior placenta	268 (91.2%)
Preoperative suspected placenta accrete	280 (95.2%)

Figs. 2,3,4 were obtained via linear regression analysis of the estimated blood loss and recovered autologous blood volume, recovered autologous blood volume and transfused autologous blood volume transfused autologous blood volume and estimated blood loss of 294 patients.

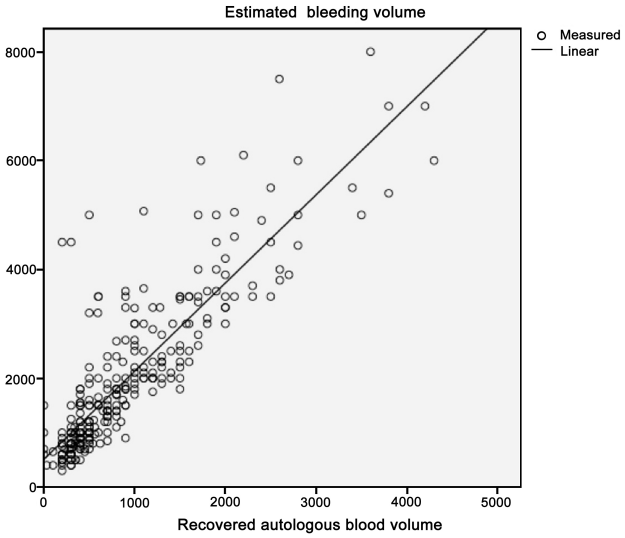

Fig. 2. Linear relationship between estimated blood loss and recovered autologous blood volume.

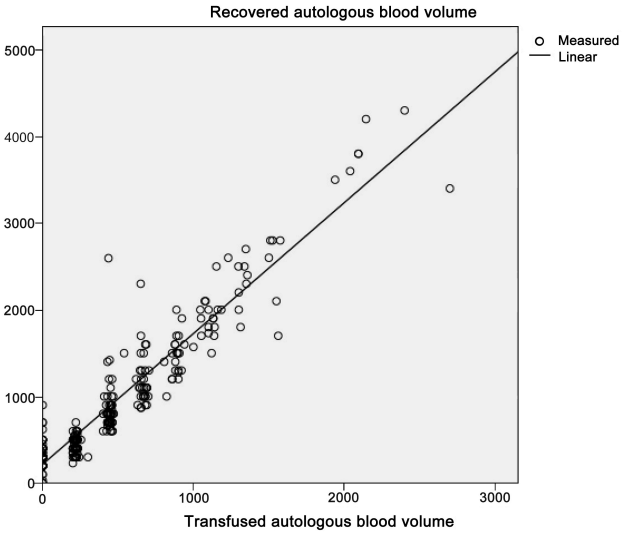

Fig. 3. Linear relationship between recovered autologous blood volume and transfused autologous blood volume.

When the estimated intraoperative blood loss was 1500 mL (Transfused autologous blood volume (mL) = 0.28 × Estimated blood loss (mL) – 96.335 mL), 324 mL of autologous blood can be transfused, which is equivalent to 1.8 U of allogeneic blood (Allogeneic blood (U) = (Autologous blood (mL)) × 50%/90 mL). If the estimated blood loss was 2000 mL, it could save 2.6 U of allogeneic blood.

Table 2. Surgical status and clinical outcomes of autologous blood recovery cases during cesarean section for placenta previa.

Surgical status and clinical outcomes	N = 294
Delivery method	
Emergency	46 (15.6%)
Elective	248 (84.4%)
Surgery time (min)	106 ± 52
Intraoperative balloon occlusion of internal iliac artery	173 (58.8%)
Postoperative uterine artery embolization	7 (2.4%)
Bladder injury	44 (15.0%)
Estimated blood loss (mL)	1979 ± 1451
Allogeneic blood transfusion	105 (35.7%)
Red blood cells (U)	2.2 ± 4.4
Plasma (mL)	260 ± 412
Autologous blood recovery (mL)	907 ± 774
Autologous blood transfusion (mL)	457 ± 485
Hysterectomy	67 (22.8%)
Re-laparotomy	2 (0.7%)
Transfer to ICU	39 (13.3%)
Adverse postnatal outcomes	9 (3.1%)
Pre-discharge hemoglobin (g/L)	101 ± 15
Second hospitalization	0 (0%)
Total hospitalization cost (¥)	37342 ± 13170
Allogeneic blood cost (¥)	1341 ± 2312
Autologous blood cost (¥)	1748 ± 430

Table 3. Comparison between autologous blood recovery and transfusion cases during cesarean section.

	Transfusion (n = 211)	Recovery (n = 83)	*p*
Age (y)	32.8 ± 4.6	33.8 ± 5.2	0.113
Prepartum BMI	26.3 ± 2.7	26.7 ± 3.6	0.313
Gestational weeks (wks)	35.8 ± 2.7	35.9 ± 2.9	0.612
Pregnancies	4 (2, 9)	4 (2, 8)	0.078
Parity	1 (1, 4)	1 (1, 3)	0.017
Number of previous cesarean sections	1 (1, 3)	1 (1, 2)	0.016
Number of previous curettages	2 (0, 6)	2 (0, 5)	0.507
Prepartum hemoglobin (g/L)	110 ± 14	115 ± 13	0.021
Vaginal bleeding in the second and third trimesters of pregnancy	63 (29.9%)	19 (22.9%)	0.231
Anterior placenta	193 (91.5%)	75 (90.4%)	0.763
Preoperative suspected placenta accreta	206 (97.6%)	74 (89.2%)	0.002
Blood loss (mL)	2429 ± 1457	836 ± 491	<0.001
Allogeneic blood cost (¥)	1790 ± 2531	200 ± 924	<0.001

4. Discussion

As early as the 19th century, the obstetrician James Blundell used autologous blood recovery for postpartum women for the first time. Although the most rudimentary methods were used for collection, filtration, and transfusion, the lives of many mothers were saved. Considering that amniotic fluid and blood were recovered together, the amniotic fluid components contained in transfused blood might have caused complications such as amniotic fluid embolism, and therefore autologous blood recovery was listed as being contraindicated during cesarean section. In recent years, with the improvements in intraoperative autologous blood recovery devices and the use of the double-tube recovery method and leukocyte filter, hospitals in many countries have resumed the use of this technology in obstetrics [4]. There have been several reports, and there are very few related complications such as amniotic fluid embolism, with only one case having been reported [5]. The United Kingdom is ranked highest in the world in the development of autologous blood recovery technology in obstetrics. The

Table 4. Preoperative suspected accreta vs. Preoperative non-accreta.

	Accreta (n = 280)	Non-accreta (n = 14)	*p*
Age (y)	33.1 ± 4.8	31.7 ± 4.5	0.278
Prepartum BMI	26.4 ± 2.9	27.8 ± 2.8	0.082
Gestational weeks (wks)	35.8 ± 4.4	35.8 ± 2.6	0.991
Pregnancies	4 (2, 9)	3 (2, 7)	0.027
Parity	1 (1, 4)	1 (1, 3)	0.396
Number of previous cesarean sections	1 (1, 3)	1 (1, 2)	0.524
Number of previous curettages	2 (0, 6)	1 (0, 5)	0.077
Prepartum hemoglobin (g/L)	112 ± 14	111 ± 16	0.2882
Vaginal bleeding in the second and third trimesters of pregnancy	43 (25.9%)	39 (30.7%)	0.364
Anterior placenta	155 (93.4%)	112 (88.2%)	0.122
Hysterectomy	65 (39.2%)	2 (1.6)	<0.001
Blood loss (mL)	2022 ± 1460	1121 ± 935	0.023
Recovered blood volume (mL)	928 ± 781	493 ± 465	0.040
Transfused blood volume (mL)	471 ± 489	169 ± 257	0.022
Total hospitalization cost (¥)	37903 ± 13066	26129 ± 10160	0.001
Autologous blood cost (¥)	1755 ± 437	1601 ± 182	0.192
Allogeneic blood cost (¥)	1369 ± 2335	782 ± 1760	0.355

Table 5. Resection of uterus vs. Retention of uterus.

	Resection of uterus (n = 67)	Retention of uterus (n = 227)	*p*
Age (y)	32.0 ± 4.3	33.4 ± 4.8	0.030
Prepartum BMI	26.5 ± 3.6	26.4 ± 2.7	0.841
Gestational weeks (wks)	35.8 ± 3.0	35.8 ± 2.7	0.980
Pregnancies	5 (2, 9)	4 (2, 8)	0.199
Parity	1 (1, 4)	1 (1, 3)	0.019
Number of previous cesarean sections	1 (1, 3)	1 (1, 2)	0.003
Number of previous curettages	2 (0, 6)	2 (0, 5)	0.706
Prepartum hemoglobin (g/L)	107 ± 14	113 ± 13	0.003
Vaginal bleeding in the second and third trimesters of pregnancy	17 (25.4%)	65 (28.6%)	0.601
Anterior placenta	64 (95.5%)	204 (89.9%)	0.152
Preoperative suspected accreta	67 (100%)	213 (93.8%)	0.037
Blood loss (mL)	3396 ± 1591	1561 ± 1104	<0.001
Recovered blood volume (mL)	1395 ± 941	763 ± 652	<0.001
Transfused blood volume (mL)	762 ± 518	367 ± 437	<0.001
Total hospitalization cost (¥)	45451 ± 11030	34949 ± 12810	<0.001
Autologous blood cost (¥)	1963 ± 577	1684 ± 353	<0.001
Allogeneic blood cost (¥)	3610 ± 3175	671 ± 1417	<0.001

use of this technology in obstetrics has been proven and is gaining in popularity; in 2005, the United Kingdom included obstetric surgery for the first time as one of the indications in its guidelines on autologous blood recovery [6]. Worldwide, there have been reports of its clinical use in the United States, Australia, Egypt, Japan, and China [7–10].

Our hospital introduced autologous blood recovery in obstetrics in 2016 and was the first hospital in Sichuan to use this technology. It has made significant savings in blood resources and shortened blood transfusion time from half an hour to about 10 minutes. It has a good safety record and can reduce complications related to allogeneic blood transfusion.

The 294 cases in this study were mainly patients with placenta previa who had a history of cesarean section, especially those with placenta accreta. The mean blood loss was 1979 ± 1451 mL, and the intraoperative blood loss was greater than 20% of blood volume. These were in line with the UK guidelines on autologous blood recovery in 2015 in which an estimated blood loss greater than 20% of blood volume was regarded as an indication for autologous blood recovery [11]. After rigorous screening and evaluation, 28.2% of patients did not reach the threshold for transfusion.

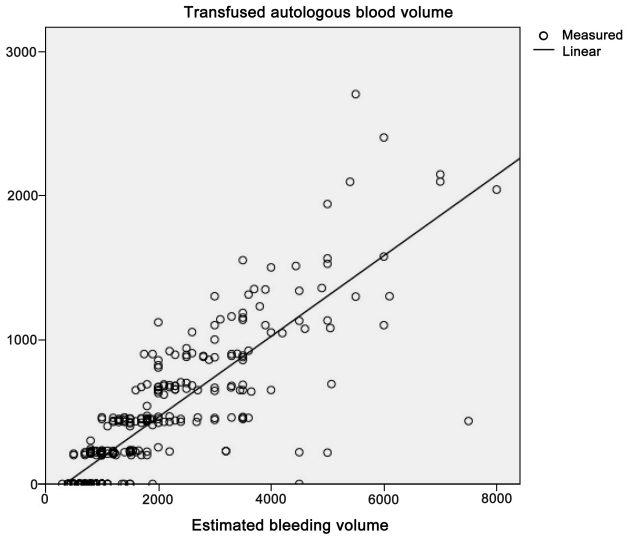

Fig. 4. Linear relationship between transfused autologous blood volume and estimated blood loss.

In our research, compared with the group without transfusion, the transfusion group had an increased parity, number of previous cesarean sections, and preoperative suspected placenta accreta, and the low hemoglobin increased the probability of transfusion. Therefore, patients with a higher parity and previous cesarean sections and preoperative suspected placenta accreta might benefit from obstetric autologous blood recovery devices. Liu *et al*. [12] had developed a scoring system to predict the cesarean hysterectomy risk in pregnant women complicated with both placenta previa and prior cesarean, helping obstetricians to make clinical decision in autologous blood use. Patients with low hemoglobin in the past also had a significantly higher probability of transfusion, and the ones who have anemia before surgery are more suitable for the option of obstetric autologous blood recovery. Besides, we found that the recovery rate, transfusion rate, blood loss, hysterectomy rate, hospitalization cost, and blood transfusion cost in the accreta group with intraoperative autologous blood were significantly higher than those in the non-accreta group and Khan *et al*. [13,14] found that the overall reduction observed in donor blood transfusion associated with the routine use of cell salvage during cesarean section was not statistically significant and the cell salvage was unlikely to be considered cost-effective.

In anticipating the need for measures to manage intraoperative bleeding, such as obstetric autologous blood recovery and preoperative balloon occlusion of the internal iliac artery, preoperative imaging such as color Doppler ultrasound and placenta MRI, should be used to evaluate the possible intraoperative blood loss. Preoperative evaluation of the presence of placenta accreta is important in choosing the surgical method, preoperative preventive measures, and deciding on intraoperative hysterectomy. Autologous blood transfusion should be offered in these cases. Patients diagnosed with placenta accreta before delivery have been shown to have significantly reduced postpartum hemorrhage and blood transfusion rate compared to those who were not diagnosed [15].

There were no serious complications such as amniotic fluid embolism, but 9 patients had adverse reactions after surgery. Among them, 7 patients had a fever after surgery and had positive bacteria cultures from uterine secretions or blood. All recovered after antibiotic treatment and had no serious complications. Both patients with thrombosis had an uneventful recovery after thrombolytic therapy.

Intraoperative autologous blood recovery in obstetrics has been considered an effective and safe auxiliary method that can save costs and time. Before using it, it is important to check for the presence of placenta accreta and evaluate preoperative anemia, and the number of previous cesarean sections, to avoid wasting obstetric autologous blood resources.

This study revealed the linear relationships between the estimated blood loss and the recovered autologous blood volume, the transfused autologous blood volume, and the recovered autologous blood volume, as well as the transfused autologous blood volume and the estimated blood loss. For the patients with a large blood loss, significant savings of allogeneic blood were made. When the estimated bleeding was 2000 mL, 2.6 U of allogeneic blood could be saved. Further, the risks of allogeneic blood transfusion were reduced, and the problems resulting from blood shortages were avoided.

At present, there are two issues affecting the use of autologous blood at our hospital. Firstly, due to the lack of anti-D immunoglobulin, our hospital has not yet applied this technology to patients with Rhesus Macacus (Rh)D-negative blood group. Secondly, due to the difficulties in adopting the technology during vaginal delivery and the problem of bacterial contamination, autologous blood transfusion has not yet been applied to patients undergoing vaginal delivery. The safety of autologous blood use in such patients needs to be confirmed by further studies.

5. Conclusions

In conclusion, intraoperative autologous blood recovery in obstetrics has been considered an effective and safe auxiliary method that can save costs. Before using it, it is important to check for the presence of placenta accreta and evaluate preoperative anemia, and the number of previous cesarean sections, to avoid wasting obstetric autologous blood resources.

Author contributions

BL and XHL designed the research study. BL performed the research. BL, JHG, MC, LL collected and analyzed the data. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

Ethics approval and consent to participate

The study was approved by the Ethics Committee of the West China Second University Hospital, Sichuan University (2017-M-033). Formal consent was required before the study and the consent paper was added in supplementary.

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Conflict of interest

The authors declare no conflict of interest.

References

[1] Koen S, Snyman LC, Pattinson RC, Makin JA. A randomised controlled trial comparing oxytocin and oxytocin + ergometrine for prevention of postpartum haemorrhage at caesarean section. South African Medical Journal. 2016; 106: 55–56.

[2] Liumbruno GM, Liumbruno C, Rafanelli D. Autologous blood in obstetrics: where are we going now? Blood Transfusion. 2012; 10: 125–147.

[3] Obstetrics Subgroup, Chinese Society of Obstetrics and Gynecology, Chinese Medical Association. Guidelines for the diagnosis and management of placenta previa (2020). Zhonghua Fu Chan Ke Za Zhi. 2020; 55: 3–8. (In Chinese)

[4] Jennings A, Brennan C. Cell salvage for obstetric patients who decline blood transfusion—a national survey. Transfusion Medicine. 2013; 23: 64–65.

[5] Oei S, Wingen G, Chantal BM, Kerkkamp HE. Cell salvage: how safe in obstetrics? International Journal of Obstetric Anesthesia. 2000; 9: 143.

[6] National Institute for Health and Clinical Excellence. Intraoperative blood cell salvage in obstetrics. 2005. Available at: https://www.nice.org.uk/guidance/ipg144 (Accessed: 1 April 2021).

[7] Rogers WK, Wernimont SA, Kumar GC, Bennett E, Chestnut DH. Acute Hypotension Associated with Intraoperative Cell Salvage Using a Leukocyte Depletion Filter during Management of Obstetric Hemorrhage Due to Amniotic Fluid Embolism. Anesthesia & Analgesia. 2013; 117: 449–452.

[8] McDonnell NJ, Kennedy D, Long LJ, Gallagher-Swann MC, Paech MJ. The Development and Implementation of an Obstetric Cell Salvage Service. Anaesthesia and Intensive Care. 2010; 38: 492–499.

[9] Elagamy A, Abdelaziz A, Ellaithy M. The use of cell salvage in women undergoing cesarean hysterectomy for abnormal placentation. International Journal of Obstetric Anesthesia. 2013; 22: 289–293.

[10] Kume K, M Tsutsumi Y, Soga T, Sakai Y, Kambe N, Kawanishi R, *et al*. A case of placenta percreta with massive hemorrhage during cesarean section. the Journal of Medical Investigation. 2014; 61: 208–212.

[11] Royal College of Obstetricians and Gynaecologists. Blood Transfusions in Obstetreics(Green-top Guideline No.47). 2015. Available at: https://www.rcog.org.uk/en/guidelines-research-services/guidelines/gtg47/ (Accessed: 1 April 2021).

[12] Liu B, Deng S, Lin M, Chen Y, Cai J, Yang J, *et al*. Prediction of cesarean hysterectomy in placenta previa complicated with prior cesarean: a retrospective study. BMC Pregnancy and Childbirth. 2020; 20: 81.

[13] Khan KS, Moore PAS, Wilson MJ, Hooper R, Allard S, Wrench I, *et al*. Cell salvage and donor blood transfusion during cesarean section: A pragmatic, multicentre randomised controlled trial (SALVO). PLoS Medicine. 2017; 14: e1002471.

[14] Khan KS, Moore P, Wilson M, Hooper R, Allard S, Wrench I, *et al*. A randomised controlled trial and economic evaluation of intraoperative cell salvage during caesarean section in women at risk of haemorrhage: the SALVO (cell SALVage in Obstetrics) trial. Health Technology Assessment. 2018; 22: 1–88.

[15] Thurn L, Lindqvist PG, Jakobsson M, Colmorn LB, Klungsoyr K, Bjarnadóttir RI, *et al.* Abnormally invasive placenta-prevalence, risk factors and antenatal suspicion: results from a large population-based pregnancy cohort study in the Nordic countries. BJOG: An International Journal of Obstetrics and Gynaecology. 2016; 123: 1348–1355.