Received: 10 December 2021 | Revised: 20 February 2022 | Accepted: 20 February 2022

DOI: 10.1111/trf.16846

TRANSFUSION

HOW DO I?

How do I perform cell salvage during vaginal obstetric hemorrhage?

Jaclyn M. Phillips[1] | **Sara Sakamoto**[1] | **Alexandra Buffie**[1] | **Selma Su**[1] | **Jonathan H. Waters**[2]

[1]Department of Obstetrics, Gynecology, & Reproductive Sciences, Division of Maternal Fetal Medicine, University of Pittsburgh Medical Center Magee-Womens Hospital, Pittsburgh, Pennsylvania, USA

[2]Department of Anesthesiology and Bioengineering, University of Pittsburgh, Pittsburgh, Pennsylvania, USA

Correspondence
Jaclyn M. Phillips, Division of Maternal Fetal Medicine, UPMC Magee-Womens Hospital, 300 Halket Street, Pittsburgh, PA 15213, USA.
Email: phillipsjm5@upmc.edu

Abstract

Background: Obstetric hemorrhage is a leading cause of preventable maternal mortality. To combat this, obstetric organizations worldwide recommend consideration of autotransfusion during severe peripartum bleeding to minimize allogenic transfusion. Current guidelines for autotransfusion in obstetrics are limited to patients undergoing cesarean birth. At present, women experiencing vaginal obstetric hemorrhage are excluded from many obstetric autotransfusion protocols. However, emerging data suggest that autotransfusion of vaginally shed blood is both safe and feasible in the obstetric patient population.

Methods and Materials: In this review, we will provide an overview of the current literature surrounding cell salvage of vaginally send blood and a detailed outline of our institution's blood collection protocol.

Results: Recent data suggests autotransfusion of vaginally shed blood is both safe and effective.

Discussion: Implementation of autotransfusion technology into the delivery room is a critical next step for the advancement of transfusion medicine in obstetrics. This review provides an overview of the data surrounding autotransfusion of vaginally shed blood during maternal hemorrhage and describes practical suggestions for how it can be effectively implemented into routine practice.

1 | INTRODUCTION

Obstetric hemorrhage requiring transfusion is a leading cause of preventable maternal morbidity and mortality worldwide.[1–3] While hemorrhage is more common in patients undergoing cesarean delivery, vaginal delivery is the most common mode of delivery, comprising approximately 70% of births in the United States. Approximately three percent of vaginal births are complicated by postpartum hemorrhage and this population represents one of the most common clinical scenarios involving obstetric hemorrhage.[3–5] Only recently has autotransfusion been recognized as a feasible tool for the management of obstetric hemorrhage, despite its longstanding use in cardiothoracic and orthopedic surgeries, among others.[6,7] Modern cell salvage protocols utilizing leukocyte depletion filters demonstrate effective removal of amniotic fluid components and microorganisms from an autologous blood product.[8,9] Obstetric organizations worldwide now recommend consideration of autotransfusion during severe peripartum bleeding.[10–13] Despite mounting evidence for cell salvage and autotransfusion in patients with vaginal obstetric hemorrhage, guidelines are currently limited to patients undergoing cesarean deliveries. Existing protocols describe blood collection techniques specific to the sterile operating room environment during

open abdominal surgery but fail to address key management techniques that are essential to consider during a vaginal obstetric hemorrhage.[14–16]

Emerging data suggests both safety and efficacy when using an autologous product from vaginally shed blood. In 2015, Teare, et al demonstrated that autologous samples generated from vaginally shed blood had comparable levels of residual bacterial contamination when compared to serum samples collected at the time of cesarean delivery. In this study, residual bacterial contamination was similar to bacterial loads seen during routine dental procedures and was deemed clinically insignificant.[17] In 2018, Lim, et al published a modern clinical cohort of 10 patients who received autotransfusion of vaginally shed blood and reported no adverse events during reinfusion. In addition, they found that maternal morbidity was comparable in cases of vaginal hemorrhage that received autologous product compared to those who did not.[18] Most recently in 2021, an abstract was published demonstrating that when matched to controls, patients who received autologous blood from vaginally shed blood had less decline in their hemoglobin between pre and post-delivery assessments.[19]

Maximizing alternative therapies to allogenic transfusion is of particular importance in the setting of limited blood bank products in light of the COVID-19 pandemic. The expeditious use of cell salvage technology during hemorrhage has been shown to reduce morbidity associated with acute blood loss and attenuate the need for allogenic blood resources.[20,21] Importantly, autotransfusion has the potential to enhance transfusion capabilities in birth centers with limited blood bank resources. Understanding how to implement autotransfusion technology into the workflow for vaginal obstetric hemorrhage is a critical next step for the advancement of transfusion medicine in obstetrics. Barriers to broader use of autotransfusion in the delivery room include lack of provider familiarity and comfort with the technique, contamination of blood with amniotic fluid from delivery, and lack of immediate access to equipment for blood collection and reinfusion. In this review, we provide a detailed report of our institution's protocol for blood collection for autotransfusion during obstetric hemorrhage.

2 | OUTCOMES IN CASES WITH AUTOTRANSFUSION OF VAGINALLY SHED BLOOD AT OUR INSTITUTION

In a recent publication, we reviewed 64 cases of autotransfusion of vaginally shed blood that occurred at our institution prior to initiation of a standardized protocol for blood collection and processing during vaginal obstetric hemorrhage.[22] We found that autotransfusion of vaginally shed blood was well tolerated and no serious adverse events were reported during administration. The majority of patients in our cohort experienced vaginal obstetric hemorrhage immediately after vaginal delivery (91%). However, there were four cases (6%) of delayed postpartum hemorrhage, which occurred anywhere from 2 to 41 days postpartum. Patients in this cohort on average received the equivalent of approximately 1.3 units of packed red blood cells in autotransfusion volume. We observed significant heterogeneity in the quantity of salvaged blood, even when controlling for blood loss. This review shed light on the need for a standardized approach to blood collection during vaginal obstetric hemorrhage.

Subsequently, our institution developed and employed the standardized protocol outlined in this review. The transition to a standardized approach for blood collection during vaginal obstetric hemorrhage had three essential components: (1) a standby system for blood collection installed in each delivery room, (2) a standardized protocol, and (3) an educational initiative for providers and staff. We observed that rates of blood collection and autotransfusion during vaginal obstetric hemorrhage significantly increased following the implementation of the standardized protocol we outline below.

3 | HOW DO I DO IT?

The process of blood collection, processing, and reinfusion is similar in cesarean delivery when compared to other surgical procedures. This technique has been previously described by Waters *et al*.[14] However, in the setting of vaginal obstetric hemorrhage, there are unique considerations required for blood collection. Vaginal delivery most often occurs in a labor and delivery room, outside of the operating room. Lack of immediate access to equipment for blood collection and autotransfusion processing typically results in blood that could otherwise be used for autotransfusion being disposed of. Blood is often lost due to contamination or spillage at the time of delivery. Here, we describe an algorithm to enhance safe blood collection in the event of hemorrhage in the delivery room (Figure 1). Amniotic fluid, fecal, and urine contamination are primarily avoided by waiting until after delivery of the baby (and surrounding amniotic fluid) to place a second under-buttocks drape for subsequent blood collection. This collected blood is then suctioned into a standby system available in the labor and delivery room. We will review each of these steps in more detail.

Step 1: Separating vaginally shed blood from amniotic fluid.

How blood is collected and suctioned is important to reduce the gross contamination of the blood and to

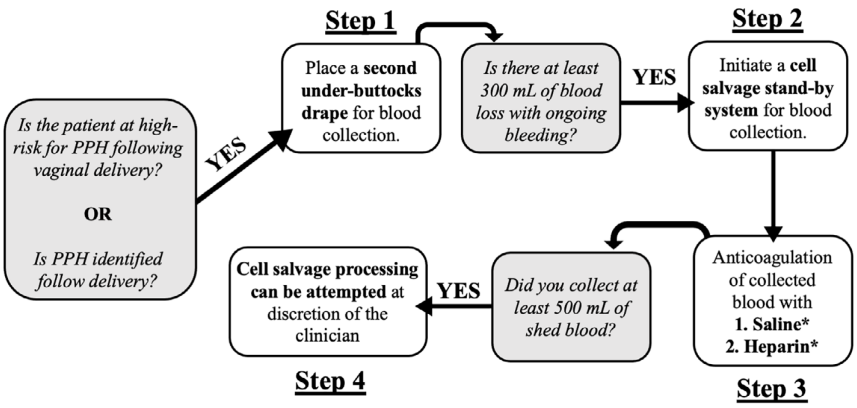

FIGURE 1 Algorithm for collection and processing of blood during vaginal obstetric hemorrhage. *Any volume of saline can be used to help suction blood from the drape as long as the total volume is recorded to keep an accurate record of estimated blood loss. The authors recommend at least 300–500 mL. †10,000 unit dose of heparin is placed into the sterile canister as soon as blood collection is initiated

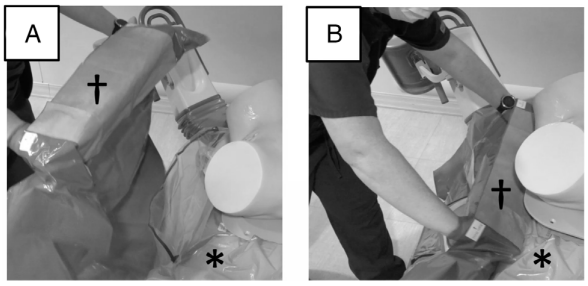

FIGURE 2 (A) Preparation and (B) placement of a second under-buttocks drape to facilitate blood collection during vaginal obstetric hemorrhage. (* = delivery drape and † = second under-buttocks drape)

enhance the quality of blood salvaged. As previously described by Waters et al., it is recommended to avoid direct suctioning of amniotic fluid at the time of delivery into the salvaged blood reservoir. During cesarean delivery, this is accomplished by a "double-suction" setup, where amniotic fluid encountered at the time of delivery is suctioned into a separate reservoir.[14] Though autotransfusion processing has the capability to significantly reduce amniotic fluid contaminants, the "double-suction" method is favored to minimize blood contamination with amniotic fluid prior to processing. In the delivery room, the lack of a contained operating room environment makes the "double-suction" method impractical. In order to separate amniotic fluid at delivery from blood, we utilize a second under-buttocks drape. Most birth centers utilize an under-buttocks drape, which is placed under the patient prior to delivery. In our protocol, following birth of the baby and release of amniotic fluid from the uterine cavity, a *second* under-buttocks drape is placed over the primary delivery drape (Figure 2A,B). This drape can be placed prophylactically for every vaginal delivery or, to reduce cost, only when obstetric hemorrhage is identified or anticipated. The second drape is imperative to blood collection in the delivery room. As providers are often busy actively evaluating and managing the postpartum hemorrhage with interventions such as fundal massage and manual uterine evacuation, any container or bin that would need to be held by the provider to collect blood would be impractical. Using a second drape allows for blood to be passively and effectively collected during vaginal obstetric hemorrhage and allows nursing and provider attention to be concentrated on direct patient care and hemorrhage management.

Step 2: Utilizing a standby system in the delivery room.

The lack of access to equipment for blood collection and storage in the delivery room is a limiting factor for the use of autotransfusion in the event of vaginal hemorrhage. Installation of a low-cost blood collection standby system in each delivery room enhances provider capability to implement collection of blood when vaginal hemorrhage occurs. A standby system includes setup of a suction reservoir, a suction line, and anticoagulant without implementing the processing bowl. Our hospital utilizes the HEMAsavR™ (Ecomed Solutions, Mundelein IL) as a standby system in each delivery room. It is a sterile blood collection device with a patient-specific liner that facilitates transfer of blood into a traditional autotransfusion collection reservoir (Figure 3A,B). We recommend initiating collection of blood into a standby system once at least 300 mL of blood is collected in the second under-buttocks drape and ongoing bleeding is anticipated (Figure 4). At least three hundred mL of normal saline is added to the second under-buttocks drape to break up existing clots and prevent clots from forming. Any volume of saline can be used to help suction blood from the drape as long as the total volume is recorded to keep an accurate record of estimated blood loss. The authors recommend using at least 300–500 mL. In addition, a 10,000 unit dose of heparin is added to the blood collection canister to minimize clotting.

It is important to remember that other key principles used to optimize blood return still apply in the setting of vaginal obstetric hemorrhage. Though most of the blood shed during vaginal obstetric hemorrhage will be collected

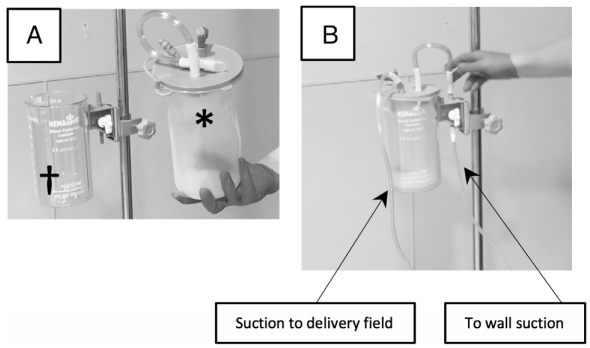

FIGURE 3 (A) Hard-shell reusable canister (†) and patient-specific liner for blood collection (*) and (B) standby system setup for the delivery room

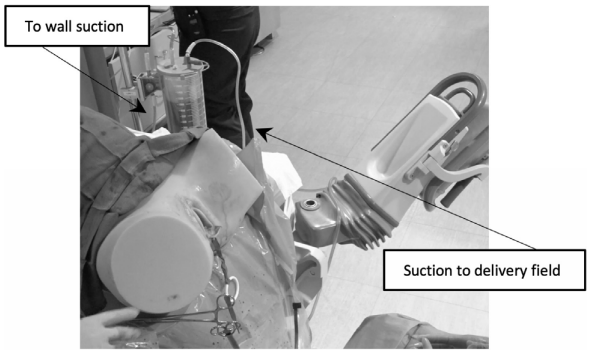

FIGURE 4 Blood collection with a standby system during vaginal obstetric hemorrhage in the delivery room

in the under-buttocks drape, a significant source of blood will be retained on sponges used on the delivery field. These sponges can be rinsed in saline solution and the rinse solution suctioned into the standby system as well. Additional principles used to optimize blood quality include suctioning from a pool of blood and utilizing suction at or below 120 mm Hg when possible to limit trauma to red blood cells.[14,23] Once blood collection is complete, the standby collection reservoir can then be taken to the device being used for blood processing. Following washing and concentration of recovered blood, utilization of a leukocyte depletion filter (Haemonetics® RS1, Haemonetics Inc., Boston, MA) will reduce fetal squamous cell, bacteria, and other residual amniotic fluid contaminants. This method has been previously described.[8,9,14]

4 | SPECIAL CONSIDERATIONS

4.1 | Moving from the delivery room to the operating room

Patients are often moved to the operating room to enhance management of severe obstetric hemorrhage. Early implementation of a blood collection protocol in the delivery room (as described above) affords the opportunity to enhance blood return and limit waste of blood that could be used for autotransfusion. If a patient requires transport to the operating room for further management, we recommend any blood in the second under-buttocks drape and standby system be brought with the patient and subsequently processed for reinfusion in the operating room. Shed blood should continue to be collected in the operating room for the duration of the hemorrhage.

4.2 | Postpartum hemorrhage outside of the delivery room

Vaginal obstetric hemorrhage is most common immediately following vaginal delivery. However, there is a subset of women who experience a delayed postpartum hemorrhage outside of the delivery room. These hemorrhages can occur during recovery from cesarean delivery, on the postpartum unit, or even in patients who are presenting from home. Our protocol can be modified for blood collection in these instances. We recommend having a standby system available in the postanesthesia care unit for patients who are recovering from cesarean delivery and supplies available on the postpartum unit for patient who experience delayed postpartum hemorrhage. Blood collection and processing can occur directly from a single under-buttocks drape, as there is no concern for amniotic fluid contamination.

4.3 | Antibiotic prophylaxis

Antibiotics are often considered in the setting of vaginal hemorrhage given the manual evacuation involved and the increased risk of endometritis as a result. Existing data demonstrate effective removal of bacterial contaminants from salvaged product, even in the setting of vaginal blood collection.[9,17] We recommend careful avoidance of blood directly contaminated with fecal matter (see contraindications). While antibiotics are not routinely employed during autotransfusion for infection prophylaxis in other clinical scenarios, we recommend considering administering antibiotics for autotransfusion for vaginal hemorrhage.[24]

4.4 | Access to perfusion services

As some hospitals do not have 24/7 access to in-house perfusionists, the option of autologous transfusion can be limited. The American Association of Blood Banks does

not limit the length of time the blood can be stored after collection before being processed.[25] Once washed and repackaged, the autologous blood has a stable shelf life of up to 4 h when blood has the appropriate anticoagulation.[23] Utilizing this protocol allows for safe blood collection and storage until the appropriate staff arrives at the hospital to process the blood for reinfusion. Importantly, the collected blood should never be separated from the patient prior to or after processing. We recommend a patient label be placed on the standby system until processing and autotransfusion are completed.

4.5 | Use with intrauterine balloon tamponade and vacuum-induced hemorrhage control devices

For atony and postpartum hemorrhage refractory to uterotonic agents, the obstetric team can utilize interventions such as balloon tamponade (e.g., Bakri® Cook Medical, Bloomington, IN) and vacuum-induced hemorrhage control devices (e.g., Jada® Alydia Health, Menlo Park, CA). Blood collected from these devices can also be used for autotransfusion. The standby system collection reservoir and suction tubing can be directly connected to the Jada system, which has been placed in the uterus, as long as low-grade suction (80–100 mmHg) is employed.

5 | CONTRAINDICATIONS

Careful attention must be paid to avoid potential blood contaminants, including direct contamination with stool, urine, cleansing agents such as betadine or hibiclens, and vasoactive medications such as misoprostol. Misoprostol is a prostaglandin E1 analog commonly used in the management of postpartum hemorrhage.[13] As misoprostol is a potent vasodilator, remnants of misoprostol tablets suctioned into salvaged blood causes theoretical concern for maternal hemodynamic effects such as profound hypotension. There are currently no available studies that describe the efficacy of cell salvage processing for removal of misoprostol from salvaged blood. Therefore, we recommend executing caution if there is any concern that savaged blood was contaminated with misoprostol. Vaginal misoprostol placed for induction of labor at doses of 25 mcg or misoprostol placed per rectum during postpartum hemorrhage is not a contraindication to autotransfusion unless the misoprostol tablets directly contaminate the salvaged blood.

6 | COST

Existing data suggests that cost-savings occur with autotransfusion when the probability of transfusion is high or in the case of obstetric hemorrhage is identified.[21] According to the latest National Blood Collection and Utilization Survey, the average cost of leukoreduced packed red blood cells is $207.[26] However, cost per unit of blood can vary widely across regions and hospital systems. Shander et al. estimates that cost per unit ranges between $332 and $717 when accounting for indirect costs (such as equipment and/or type and cross).[27] In contrast, the disposable components of a complete autotransfusion setup costs about $125.[21]

Cost data regarding autotransfusion is currently limited to cesarean delivery and there are no large-scale studies that report a cost-effectiveness analysis for patients who experience vaginal hemorrhage.. In 2018, Khan et al published a large multicenter randomized control trial evaluating the use of cell salvage compared to routine care during cesarean delivery. This trial performed a cost-effectiveness analysis, however, a limitation of this study was that it was not specific for high-risk patients, and cell salvage processing occurred in all cases.[28] Other cost-effectiveness studies consistently demonstrate that cell salvage use for obstetric cases at high-risk for hemorrhage or when obstetric hemorrhage is reasonable and cost-effective.[21,29] However, routine use of cell salvage in low-risk patients is not cost-effective.[21,29]

Extrapolating from the existing cesarean delivery data, cell salvage use is promising and has the potential to be cost-effective in the broader field of obstetrics, including vaginal delivery. More data are needed to better understand the cost-effectiveness of implementing a protocol for blood collection and cell salvage processing in the event of vaginal obstetric hemorrhage. One reasonable assumption, however, would be that total blood loss, ability to recover and utilize autologous blood for transfusion, and the overall rate of allogenic blood transfusion would be less for vaginal versus cesarean deliveries. Utilizing a standby system, like the one described above, may improve the cost-effectiveness of cell salvage for vaginal hemorrhage. With a standby system, providers can implement blood collection immediately, but reserve blood processing (and the cost of processing) with cell salvage equipment only after sufficient blood has been collected. At our institution, we have elected to utilize a second under-buttocks drape ($2) and a HEMAsavR™ standby system (average disposable cost $30[30]) for select patients either experiencing or are deemed high-risk for postpartum hemorrhage.

7 | CONCLUSION

Rates of severe obstetric hemorrhage continue to rise in the United States.[1,3] Autotransfusion remains an underutilized therapy in the delivery room during vaginal hemorrhage. We report a novel protocol for optimizing blood collection and processing in the delivery room. Early implementation of this protocol in the delivery room can significantly enhance the volume of blood recovered at the time of vaginal hemorrhage. Autotransfusion in these cases has the potential to minimize patient exposure to allogenic blood and allow for judicious use of limited blood bank resources.

CONFLICT OF INTEREST

Jonathan H. Waters belongs to the strategic advisory committee for Haemonetics, and is a consultant for LivaNova. The other authors have no conflicts of interest to disclose.

ORCID

Jaclyn M. Phillips https://orcid.org/0000-0002-2439-0686
Jonathan H. Waters https://orcid.org/0000-0001-9057-6086

REFERENCES

1. Bateman BT, Berman MF, Riley LE, Leffert LR. The epidemiology of postpartum hemorrhage in a large, nationwide sample of deliveries. Anesth Analg. 2010;110(5):1368–73. https://doi.org/10.1213/ANE.0b013e3181d74898
2. Reale SC, Easter SR, Xu X, Bateman BT, Farber MK. Trends in postpartum hemorrhage in the United States from 2010 to 2014. Anesth Analg. 2020;130(5):e119–22. https://doi.org/10.1213/ANE.0000000000004424
3. Ahmadzia HK, Grotegut CA, James AH. A national update on rates of postpartum haemorrhage and related interventions. Blood Transfus. 2020;18(4):247–53. https://doi.org/10.2450/2020.0319-19
4. Wilson MJA, Wrench IJ. Cell salvage for vaginal delivery - is it time we considered it? Int J Obstet Anesth. 2015;24(2):97–9. https://doi.org/10.1016/j.ijoa.2015.03.002
5. Dupont C, Touzet S, Colin C, Deneux-Tharaux C, Rabilloud M, Clement HJ, et al. Incidence and management of postpartum haemorrhage following the dissemination of guidelines in a network of 16 maternity units in France. Int J Obstet Anesth. 2009;18(4):320–7. https://doi.org/10.1016/j.ijoa.2009.02.017
6. Konig G, Waters JH. Washing and filtering of cell-salvaged blood - does it make autotransfusion safer? Transfus Altern Transfus Med. 2012;12(3–4):78–87. https://doi.org/10.1111/j.1778-428X.2012.01155.x
7. Roets M, Sturgess DJ, Wyssusek K, van Zundert AA. Intraoperative cell salvage: a technology built upon the failures, fads and fashions of blood transfusion. Anaesth Intensive Care. 2019;47(3_suppl):17–30. https://doi.org/10.1177/0310057X19860161
8. Waters JH, Biscotti C, Potter PS, Phillipson E. Amniotic fluid removal during cell salvage in the cesarean section patient. Anesthesiology. 2000;92(6):1531–6. https://doi.org/10.1097/00000542-200006000-00008
9. Waters JH, Tuohy MJ, Hobson DF, Procop G. Bacterial reduction by cell salvage washing and leukocyte depletion filtration. Anesthesiology. 2003;99(3):652–5. https://doi.org/10.1097/00000542-200309000-00021
10. Intraoperative blood cell salvage in obstetrics. Interventional procedure guidance. National Institute for Health and Clinical Excellence (NICE). https://www.nice.org.uk/guidance/ipg144/resources/intraoperative-blood-cell-salvage-in-obstetrics-pdf-1899863219663557.
11. OAA/AAGBI guidelines for obstetric anaesthetic services. Revised edition. London. https://www.oaa-anaes.ac.uk/assets/_managed/editor/File/Guidelines/obstetric_anaesthetic_services_2013.pdf. Published 2013.
12. Committee on obstetric practice. Committee opinion no. 529: placenta accreta. Obstet Gynecol. 2012;120(1):207–11. https://doi.org/10.1097/AOG.0b013e318262e340
13. Practice Bulletin No. 183: Postpartum Hemorrhage. Obstet Gynecol. 2017;130(4):e168–86. https://doi.org/10.1097/AOG.0000000000002351
14. Waters JH, Beck S, Yazer MH. How do I perform cell salvage in obstetrics? Transfusion. 2019;59(7):2199–202. https://doi.org/10.1111/trf.15352
15. Allam J, Cox M, Yentis SM. Cell salvage in obstetrics. Int J Obstet Anesth. 2008;17(1):37–45. https://doi.org/10.1016/j.ijoa.2007.08.001
16. Sullivan JV, Crouch ME, Stocken G, Lindow SW. Blood cell salvage during cesarean delivery. Int J Gynecol Obstet. 2011;115(2):161–3. https://doi.org/10.1016/j.ijgo.2011.06.009
17. Teare KM, Sullivan IJ, Ralph CJ. Is cell salvaged vaginal blood loss suitable for re-infusion? Int J Obstet Anesth. 2015;24(2):103–10. https://doi.org/10.1016/j.ijoa.2014.12.001
18. Lim G, Kotsis E, Zorn JM, Dalby PL, Ralph CJ, Waters JH. Cell salvage for postpartum haemorrhage during vaginal delivery: a case series. Blood Transfus. 2018;16(6):498–501. https://doi.org/10.2450/2017.0155-17
19. Phillips JM, Waters J, Larkin J, Tamura T, Sakamoto S. 550 autotransfusion of vaginally shed blood during obstetric hemorrhage: a matched cohort atudy. Am J Obstet Gynecol. 2021;224(2):S347–8. https://doi.org/10.1016/j.ajog.2020.12.571
20. Carless PA, Henry DA, Moxey AJ, O'Connell D, Brown T, Fergusson DA. Cell salvage for minimising perioperative allogeneic blood transfusion. In: Carless PA, editor. Cochrane database of systematic reviews. John Wiley & Sons, Ltd: Chichester, UK; 2010. https://doi.org/10.1002/14651858.CD001888.pub4
21. Milne ME, Yazer MH, Waters JH. Red blood cell salvage during obstetric hemorrhage. Obstet Gynecol. 2015;125(4):919–23. https://doi.org/10.1097/AOG.0000000000000729
22. Phillips JM, Tamura T, Waters JH, Larkin J, Sakamoto S. Autotransfusion of vaginally shed blood as a novel therapy in obstetric hemorrhage: a case series. Transfusion. 2022. https://doi.org/10.1111/trf.16794. Online ahead of print.
23. Waters JH. Red blood cell recovery and reinfusion. Anesthesiol Clin North Am. 2005;23(2):283–94. https://doi.org/10.1016/j.atc.2005.02.001

24. Waters JH. Cell salvage in trauma. Curr Opin Anaesthesiol. 2021;34(4):503–6. https://doi.org/10.1097/ACO.0000000000001014
25. Standards for perioperative autologous blood collection and administration (perioperative standards). Bethesda, Maryland: American Association of Blood Banks; 2021.
26. Sapiano MRP, Jones JM, Savinkina AA, Haass KA, Berger JJ, Basavaraju SV. Supplemental findings of the 2017 National Blood Collection and utilization survey. Transfusion. 2020;60-(Suppl 2):S17–37. https://doi.org/10.1111/trf.15715
27. Shander A, Hofmann A, Ozawa S, Theusinger OM, Gombotz H, Spahn DR. Activity-based costs of blood transfusions in surgical patients at four hospitals. Transfusion. 2010; 50(4):753–65. https://doi.org/10.1111/j.1537-2995.2009.02518.x
28. 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 Technol Assess (Rockv). 2018;22(2):1–88. https://doi.org/10.3310/hta22020
29. Lim G, Melnyk V, Facco FL, Waters JH, Smith KJ. Cost-effectiveness analysis of intraoperative cell salvage for obstetric hemorrhage. Anesthesiology. 2018;128(2):328–37. https://doi.org/10.1097/ALN.0000000000001981

How to cite this article: Phillips JM, Sakamoto S, Buffie A, Su S, Waters JH. How do I perform cell salvage during vaginal obstetric hemorrhage? Transfusion. 2022;https://doi.org/10.1111/trf.16846