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ORIGINAL ARTICLE

Autotransfusion in emergent operative trauma resuscitation

X. A. Caliste · K. A. McArthur · J. A. Sava

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Abstract
Purpose Autotransfusion of red cells is common in many surgical specialties. However, this technique is not uniformly used in abdominal trauma. The purpose of this paper is to study the outcomes of patients who were autotransfused during emergency trauma operations in which they sustained full-thickness hollow viscus injury (HVI).
Methods A total of 179 patients in period 1999–2008 with penetrating and blunt abdominal trauma requiring intraoperative blood transfusion were evaluated. Recipients of autotransfusion and banked blood (autotransfused group) were compared with recipients of banked blood products only (control group). The *t*-test, Chi-squared, and Fisher's exact test were used to evaluate the data. Multivariate regression analysis evaluated the primary outcomes, survival and bloodstream infection (BSI).
Results Of the 179 patients, 108 controls and 71 autotransfused patients were evaluated. The results showed no statistically significant difference between the control and autotransfusion groups regarding age, injury pattern/severity [Injury Severity Score (ISS)], length of stay, postoperative international normalized ratio (INR), and volume of banked blood products. Both groups were also proportional with colon injury. The estimated operative blood loss (EBL) was 2,472 ± 3,261 for controls and 4,056 ± 3,825 for the autotransfused group ($p = 0.0001$). The total volume of blood transfused was 2,792 and 5,513 for controls and patients in the autotransfusion group, respectively ($p = 0.002$). Ninety controls (84 %) and 53 autotransfused patients (76 %) survived to discharge ($p = 0.21$). Twenty controls (49 %) and 17 autotransfused patients (45 %) developed BSI ($p = 0.72$). Logistic regression analysis revealed that an ISS >25, systolic blood pressure <90, and EBL >2 L predicted mortality. There was also a trend towards decreased survival with age >50 years.
Conclusion We found no evidence that emergent autotransfusion worsens clinical outcomes in the setting of concomitant HVI.

Keywords Abdominal trauma · Emergency surgery · Shock · Trauma systems · Infection · Autotransfusion

Introduction

Autologous blood transfusion has been available for over a century, but its use has been inconsistent in different surgical specialties. It is a common technique in cardiac and hepatobiliary surgery, but is not uniformly used in trauma, particularly in shocked patients sustaining penetrating abdominal injury. Understandably, there is concern about the potential for infectious complications after autotransfusion in the setting of hollow viscus injury (HVI), though there is little evidence to guide surgeons.

The purpose of this study is to evaluate the outcomes of patients undergoing emergency surgery for penetrating and

X. A. Caliste
Department of Vascular Surgery, University of Rochester Medical Center, 601 Elmwood Avenue, Box 652, Rochester, NY 14642, USA
e-mail: xzabia_caliste@urmc.rochester.edu

K. A. McArthur · J. A. Sava (✉)
Department of General Surgery, Trauma Service, Washington Hospital Center, 110 Irving Street NW, Room 4B-39, Washington, DC 20010, USA
e-mail: jack.a.sava@medstar.net

blunt injury who have sustained full-thickness HVI and received autologous blood transfusion. We hypothesize that, among patients with HVI, those receiving autologous blood products would not have a higher mortality or bloodstream infection (BSI) rate than those receiving banked blood products only.

Materials and methods

Eligibility

A retrospective cohort analysis of the trauma registry of Washington Hospital Center, a Level I Trauma Center, was conducted with the approval of the hospital Internal Review Board. Trauma victims with HVI who required emergency surgery with intraoperative blood transfusion during the period 1999–2008 were identified. Autotransfused patients were compared with recipients of banked blood products only (control group). HVI was defined by operative notes describing full-thickness stomach, small bowel (SB), or colorectal injury. Categorical variables such as age were arbitrarily divided at common cutoffs. The demographics, injury pattern/severity [Injury Severity Score (ISS)], Penetrating Abdominal Trauma Index (PATI), the base deficit, initial systolic blood pressure (SBP) upon arrival, volume of banked/autotransfused blood given, and estimated operative blood loss (EBL) were documented, as were clinical outcomes, including survival to hospital discharge, length of stay (LOS), postoperative international normalized ratio (INR), and BSI. BSI was defined as positive blood cultures during admission. Patients that expired within 24 h of admission did not have blood cultures performed.

During the study period, autotransfusion was used at the discretion of the attending surgeon when there was massive hemoperitoneum or perceived risk for exsanguinating hemorrhage. The autotransfusion team was on call and in the hospital 24 h a day, 7 days per week, and they were able to set up and initiate autotransfusion within minutes. The standard protocol is described below. All patients received perioperative antibiotics.

Statistical analysis

The primary outcomes of interest were BSI and survival.

Bivariate comparisons between the study groups were conducted using two-sample *t*-tests and nonparametric rank tests for continuous variables and the Chi-squared and Fisher's exact tests for categorical variables. Multivariate logistic regression analysis was performed to evaluate the primary outcomes by adjusting for confounders.

Table 1 Demographic data of the control and autotransfusion groups

	Controls	Autotransfusion	*p*-values
Age (years)	30 ± 13	30 ± 11	0.72
ISS	19 ± 12	20 ± 13	0.50
SBP	99 ± 41	89 ± 48	0.20
EBL (L)	2.4 ± 3.3	4.1 ± 3.8	0.0001

Autologous transfusion technique

Intraoperative blood salvage occurred via the autoLog Autotransfusion System by Medtronic, Inc. (Minneapolis, MN). A double-lumen suction tube is inserted into the abdominal cavity to aspirate blood, which is subsequently collected in a reservoir. As the aspirate is collected, it is mixed with an anticoagulant, typically heparin. This anticoagulant is also used to preprime the reservoir. The contents of the reservoir are macrofiltered to remove large clots and debris. The blood is then drawn from the reservoir into the centrifuge for further processing. Centrifuging results in the higher density red blood cells separating from the plasma and other contents and adhering to the sides of the centrifuge machine. Sterile, isotonic saline is then pumped into the centrifuge to wash its contents. The less dense material, white blood cells, platelets, plasma, clotting factors, and anticoagulant, are maintained in the center of the centrifuge and are subsequently delivered to the waste bag. Waste products are collected in the waste bag and appropriately discarded. The red blood cells are subsequently collected in the reinfusion bag for return to the patient.

Results

One hundred seventy-nine penetrating and blunt trauma patients who had HVI and required red blood cells transfusion were identified from the trauma registry. Of these patients, 108 were categorized as the control group (recipients of banked blood products only) and 71 patients were placed in the autotransfusion group (recipients of salvaged and banked blood products). There were 95 male (88 %) and 13 female patients in the control group and 66 males (93 %) and five females in the autotransfusion group ($p = 0.28$). The average patient in both groups was approximately 30 years of age ($p = 0.72$) (Table 1).

Mechanism and type of injury

Figure 1 depicts the mechanisms of injury sustained by both groups. Gunshot wounds were the predominant mode of injury, followed by stab wounds.

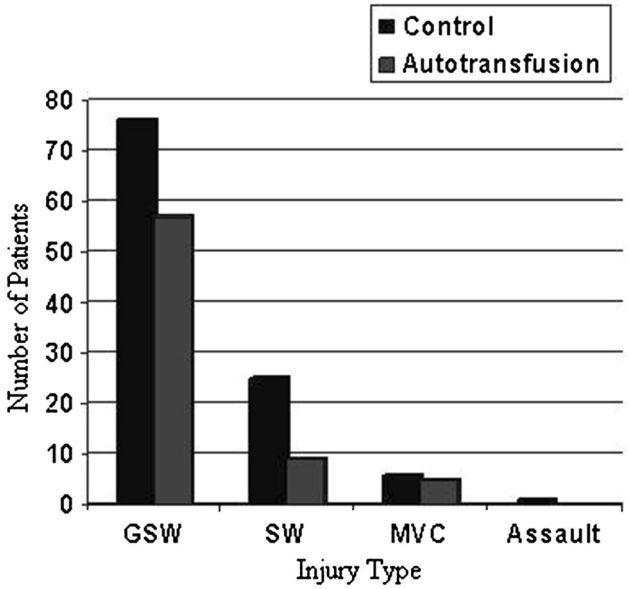

Fig. 1 Mechanism of injury: *GSW* gunshot wound, *SW* stab wound, *MVC* motor vehicle collision, assault

Table 2 Hollow viscus injury (HVI) by type

	Control	Autotransfusion	*p*-value
Colorectal	55 (63 %)	33 (38 %)	0.86
Small bowel	76 (64 %)	42 (36 %)	0.51
Gastric	40 (57 %)	30 (43 %)	0.34

Colorectal injury (CR only, CR and SB, CR and gastric), small bowel injury (SB only, SB and CR, SB and gastric), gastric injury (gastric only, G and SB, G and CR)

Table 2 depicts the type of HVI resulting from the mechanisms of injury described above. The numbers add up to more than 100 % because they take into account the combination of injuries suffered by multiple patients. Differences between autotransfusion and control patients in the distribution of colorectal, SB, and gastric injuries did not reach statistical significance ($p = 0.61$).

Severity of injury and volume of blood loss

The mean ISS score for patients in the control group was 19 ± 12 and 20 ± 13 for recipients of autologous transfusion ($p = 0.5$). Although there was no significant difference between the groups in injury severity, there was a statistically significant difference in blood loss. EBL was $2{,}472 \pm 3{,}261$ for controls and $4{,}056 \pm 3{,}825$ for the autotransfused patients (t-test $p = 0.003$; Mann–Whitney rank test $p = 0.0001$). There was no statistically significant difference in the initial SBP of the control group (99 ± 41) versus the autologous transfusion group (89 ± 48) ($p = 0.2$) (Table 1).

Table 3 Volume of intraoperative blood products transfused

	Control	Autotransfusion	*p*-values
pRBCs (ml)	$1{,}685 \pm 2{,}013$	$2{,}023 \pm 2{,}047$	0.28
FFP (ml)	$609 \pm 1{,}527$	$895 \pm 1{,}586$	0.23
Platelets (ml)	$497 \pm 1{,}165$	$925 \pm 1{,}583$	0.05
Autotransfused blood (ml)	0	$1{,}670 \pm 2{,}671$	0.0001
Total volume (ml)	$2{,}792 \pm 4{,}705$	$5{,}513 \pm 7{,}887$	0.002

Table 4 Outcomes

	Control	Autotransfusion	*p*-value
Survival	90 (84 %)	53 (76 %)	0.21
BSI	20 (49 %)	17 (45 %)	0.72
LOS (days)	17 ± 19	18 ± 23	0.81
INR	1.3 ± 1.1	1.5 ± 1.0	0.24

Volume of blood products transfused intraoperatively

Table 3 depicts the volume of blood products transfused intraoperatively to both the control and the autotransfusion groups. Although, on average, the patients receiving autologous transfusion received more banked blood products than the controls, the difference only reached statistical significance in the number of platelet products transfused. The total blood transfused was almost double in the autotransfusion group, and this difference was statistically significant (t-test $p = 0.0003$; Mann–Whitney rank test $p = 0.002$).

Coagulopathy

The postoperative INR was used to evaluate coagulopathy. The mean INR was 1.3 for the recipients of banked blood only and 1.5 for those given banked and autologous blood ($p = 0.24$) (Table 4).

Bloodstream infection

After excluding 67 patients from the control group and 33 patients from the autotransfusion group, that either died within 24 h of admission or never had blood cultures performed, 20 patients in the control group (49 %) and 17 (45 %) in the autotransfused group were found to have BSIs ($p = 0.72$) (Table 4). Figure 2 illustrates the species grown from blood cultures acquired from either group. The

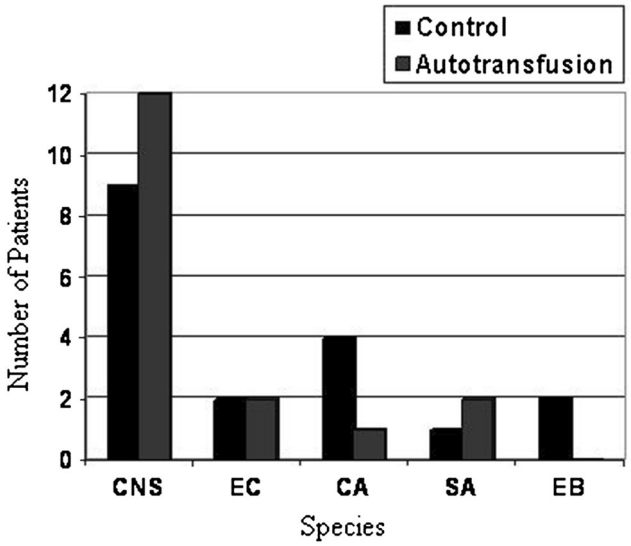

Fig. 2 Bloodstream infection (BSI) speciation: *CNS* coagulase-negative *Staphylococcus*; *EC Enterococcus*; *CA Candida*; *SA Staphylococcus Aureus*; *EB Enterobacter*

Table 5 Logistic regression analysis: bloodstream infection (BSI)

	Odds ratio	*p*-value	95 % CI
Age > 50 years	3.5	0.08	0.88–14
ISS > 25	2.2	0.06	0.96–4.9
EBL > 2 L	0.99	0.98	0.43–2.3
SBP > 90	2.1	0.10	0.87–4.9
Autotransfusion	1.6	0.23	0.74–3.6

$n = 179$ patients

Table 6 Logistic regression analysis: survival

	Odds ratio	*p*-value	95 % CI
Age > 50 years	0.74	0.72	0.14–3.8
ISS > 25	0.19	0.001	0.07–0.50
EBL > 2 L	0.12	0.000	0.04–0.35
SBP > 90	3.6	0.01	1.3–9.6
Autotransfusion	1.1	0.81	0.42–3.0

$n = 179$ patients

predominant speciation was coagulase-negative *Staphylococcus*. Logistic regression analysis verified that age > 50 years, ISS > 25, EBL > 2 L, SBP < 90, and use of autotransfusion did not predict BSIs (Table 5).

Survival

Fifty-three (76 %) of the autotransfused patients survived to discharge, compared to 90 (84 %) controls ($p = 0.21$) (Table 4). Logistic regression showed that ISS > 25, SBP < 90, and EBL > 2 L predicted mortality (Table 6). There is a trend towards decreased survival with age > 50 years. Multivariate analysis also showed that survival in autotransfused patients was not significantly lower than in controls ($p = 0.81$).

Length of stay

There was no statistically significant difference in the mean LOS between the control and autotransfusion groups ($p = 0.81$) (Table 4).

Discussion

The first use of autotransfusion was described by Blundell in 1818 in the treatment of postpartum hemorrhage [1]. Van Schaik first described its use in abdominal trauma in 1927 [2]. Despite its existence for over a century, the extent of the use of autologous transfusion in emergency trauma operations in patients sustaining HVI is not well known. Some surgeons never use autotransfusion, some abort it upon discovering HVI, and some continue to autotransfuse despite contamination, especially if the patient is profoundly shocked and actively bleeding. They rely on the filtering of the autotransfusion device to remove infectious agents.

The availability of banked blood may impact the use of salvaged blood as well [3]. HVI is often considered a contraindication to autotransfusion due to the potential infusion of contaminants [4–7]. Boudreaux et al. showed that the washing of red blood cells does not rid them of all bacterial contaminants [8].

Despite these concerns, some authors have advocated use of autotransfusion after HVI [3, 9, 10]. Some authors have suggested that transfusion after mild contamination is well tolerated versus transfusion with extensive contamination from colonic injury [11]. Ozmen et al. studied 152 patients sustaining penetrating abdominal trauma resulting in intestinal injuries, 50 of which received banked blood products only and 20 of which were autotransfused. There was no significant increase found in the site-specific infection risk in the autotransfused group [12]. In a study of 44 patients with penetrating torso injury, Bowley et al. reported no difference in mortality and postoperative infection rates [9]. Autotransfusion offers a decreased risk of blood-bourne infection and transfusion-related reactions [12–14].

We found no statistically significant difference in mortality or infection rates between patients with HVI receiving autologous transfusion and those with HVI receiving banked blood products only. There was a trend towards decreased survival in the autotransfused group, but the

confidence interval was wide and it did not reach statistical significance. Interestingly, the autotransfused patients had dramatically greater blood loss and received a much higher total blood product transfusion. Also, there was a trend towards a lower initial SBP in the autotransfused group. This suggests that, on the whole, autotransfused patients are more physiologically compromised than those receiving banked blood. This is not surprising, since the decision to autotransfuse despite HVI is likely often made in fairly desperate circumstances, and, in this study cohort, this was likely the case. Thus, there is an inherent bias present that allocates the sickest patients to the autotransfused group. Despite this bias, these patients' outcomes were comparable to the control group. Nonetheless, it is possible that a bigger dataset would reveal significant differences between groups.

Another limitation to this study may lie in its design as a retrospective review, as well as case-mix variation between groups. We controlled for common risks like ISS and EBL, but trauma patients have a wide variety of injury constellations, and these were not fully addressed in our analysis. Multiple injuries could have added to the resuscitation requirements of the study cohort. Variations in care over the time span of this study could also contribute to limitations in data analysis. Also, greater breadth and uniformity in physiologic data (i.e., lactate levels, initial arterial blood gas levels) would have improved our analysis of the extent of physiologic compromise experienced by patients in each group. Our sample size may have led us to miss small outcome differences between groups. Finally, we were unable to find consistent documentation on the degree and location of spillage, as the degree of contamination was rarely documented. This information might have influenced the decision to autotransfuse, as well as infection rates.

We found no evidence of worse outcomes in autotransfused patients with HVI compared to controls receiving banked blood only. Autologous transfusion is a viable option to be considered in emergent trauma situations, particularly when the availability of banked blood is limited.

Conflict of interest Xzabia A. Caliste, Karina A. McArthur and Jack A. Sava declare that they have no conflict of interest.

Compliance with ethical statements All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

References

1. Blundell J. Experiments on the transfusion of blood by the syringe. Med Chir Trans. 1818;9(Pt 1):56–92.
2. Van Schaik HD. Penetrating wounds of the abdomen. J Florida Med Assoc. 1927;14:33–4.
3. Glover JL, Smith R, Yaw PB, Radigan LR, Bendick P, Plawecki R. Autotransfusion of blood contaminated by intestinal contents. JACEP. 1978;7(4):142–4.
4. Duncan SE, Klebanoff G, Rogers W. A clinical experience with intraoperative autotransfusion. Ann Surg. 1974;180(3):296–304.
5. Horst HM, Dlugos S, Fath JJ, Sorensen VJ, Obeid FN, Bivins BA. Coagulopathy and intraoperative blood salvage (IBS). J Trauma. 1992;32(5):646–53.
6. Jacobs LM, Hsieh JW. A clinical review of autotransfusion and its role in trauma. JAMA. 1984;251(24):3283–7.
7. Young GP, Purcell TB. Emergency autotransfusion. Ann Emerg Med. 1983;12:180–6.
8. Boudreaux JP, Bornside GH, Cohn I Jr. Emergency autotransfusion: partial cleansing of bacteria-laden blood by cell washing. J Trauma. 1983;23(1):31–5.
9. Bowley DM, Barker P, Boffard KD. Intraoperative blood salvage in penetrating abdominal trauma: a randomised, controlled trial. World J Surg. 2006;30(6):1074–80.
10. Timberlake GA, McSwain NE Jr. Autotransfusion of blood contaminated by enteric contents: a potentially life-saving measure in the massively hemorrhaging trauma patient? J Trauma. 1988;28(6):855–7.
11. Jurkovich GJ, Moore EE, Medina G. Autotransfusion in trauma. A pragmatic analysis. Am J Surg. 1984;148(6):782–5.
12. Ozmen V, McSwain NE Jr, Nichols RL, Smith J, Flint LM. Autotransfusion of potentially culture-positive blood (CPB) in abdominal trauma: preliminary data from a prospective study. J Trauma. 1992;32(1):36–9.
13. Biffl WL, Moore EE. Transfusion alternatives in trauma. Transfus Med. 1999;1(2):5–12.
14. Sugai Y, Sugai K, Fuse A. Current status of bacterial contamination of autologous blood for transfusion. Transfus Apher Sci. 2001;24(3):255–9.