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The Impact of Three Different Wash Solutions on Autotransfusion Products

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Abstract: Many blood conservation techniques and strategies have been implemented to aid in decreasing the use of allogenic blood utilization during pediatric cardiothoracic surgery. Use of techniques, such as acute normovolemic hemodilution, retrograde autologous prime, venous autologous prime, and autotransfuion, may lead to a decrease in the need for allogenic blood products. Autotransfusion has become a standard of care for all cardiothoracic surgical procedures requiring cardiopulmonary bypass (CPB). Although widely used, there is still debate over which wash solution will produce the most physiologically normal autotransfusion product. Pediatric patients can be at a higher risk for electrolyte imbalance intraoperatively and postoperatively. In an attempt to minimize this, we sought out to evaluate three different wash solutions and how they would affect the final autotransfusion product. This comparison consisted of three wash solutions; .9% sodium chloride, Normosol-R™, and Plasma-Lyte A. Based on the evaluation of all wash solutions, Plasma-Lyte A produced the most physiological normal final autotransfusion product in regards to electrolytes. **Keywords:** cardiopulmonary bypass, cell saver, autotransfusion product, blood loss, electrolyte imbalance, pediatrics. *J Extra Corpor Technol. 2018;50:113–6*

Allogenic blood transfusion during pediatric cardiac surgery using cardiopulmonary bypass (CPB) is needed but can negatively impact the outcome after these procedures (1). In an effort to decrease the rate of blood transfusions and its associated negative sequelae, autotransfusion has become a standard of care for cardiothoracic surgery requiring CPB. As stated by the Society of Thoracic Surgeons blood conservation strategy recommendations, autotransfusion is a vital technique to avoid unnecessary allogenic blood transfusions (2,3). Although autotransfusion is widely used, there is some debate over which wash solution would produce a physiologically normal autotransfusion product. The most commonly used wash solution in standard centrifuge-based autotransfusion is .9 normal saline (NS) (4). The composition of a wash solution can play a major role in achieving a physiologically normal autotransfusion product (5). This becomes very important for the patients' electrolyte balance preoperatively, intraoperatively, and postoperatively especially when utilizing large volumes of autotransfusion products. This impact is even more evident when it comes to the pediatric patient population. In some instances, a pediatric patient may receive volume replacement equivalent to a large percentage of total circulating blood volume using autotransfusion products. This impact was evident, as we observed that some of our patients experienced hypernateremia postoperatively in the cardiothoracic intensive care unit after receiving large volumes of autotransfusion products. This was corrected when we switched our wash solution to Normosol®-R (Hospira, Inc., Lake Forest, IL). In an effort to demonstrate the impact of the type of wash

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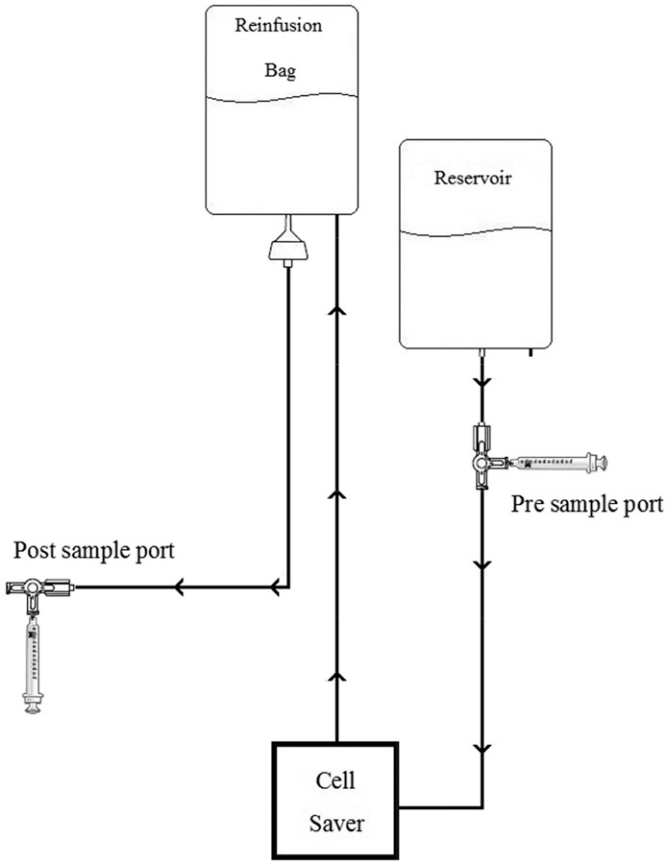

Figure 1. Blood and wash solution were mixed in reservoir. Pre wash sample taken from sample port and sent for analysis. Wash cycle started per instructions for use, once wash cycle completed, one save final spin was completed. After mixing post wash sample in the reinfusion bag, post sample was drawn and sent for analysis.

solution on the final autotransfusion products, we decided to compare three commonly used wash solutions and evaluate the final autotransfusion product. This included .9% NS (Baxter, Deerfield, IL), Normosol®-R (Hospira, Inc.), Plasma-Lyte A (Baxter) (Table 1). Therefore, we hypothesized that utilizing Normosol®-R would produce a more physiologically normal final autotransfusion product compared with our current wash solution .9% NS.

METHODS

Five units of expired homologous packed red blood cells (PRBCs) were obtained from the blood bank at our institution. All PRBC units were the same blood type and stored in anticoagulant citrate dextrose solution USP (ACD; Fenwal, Inc., Lake Zurich, IL). All PRBCs were then pooled into a two liter collection bag and gently mixed to allow for homogenous product. A single Fresenius continuous autotransfusion system (CATS) (Fresenius Kabi AG, Homburg, Germany) was used for all processing cycles. PRBCs (120 mL) were then aliquoted from the collection bag into a filtered Terumo CATS reservoir for each wash cycle. After placing the PRBCs into the reservoir, 240 mL of wash solution was added to the reservoir to clear the filter and hemodilute the PRBCs, according to our clinical practices. Each wash solution added to the reservoir was the respective solution being examined for that cycle. Blood samples were assayed at the outlet of the reservoir from a stopcock located directly below the CATS reservoir after insuring the reservoir was mixed well (Figure 1). The blood and wash solution were then processed according to the CATS instructions for use using the high-quality wash program. The final product was then assayed from the reinfusion bag after insuring it was well mixed. The cell saver disposal kit was then discarded and a new kit was placed in the cell saver before performing another wash cycle. The previous process was repeated three times for each wash solution examined. All samples where tested for glucose, chloride, potassium, sodium, phosphate, magnesium, calcium, and hemoglobin/hematocrit (Table 2). The wash solution that produced the most physiologically normal autotransfusion product was determined by how many data points fell within normal range post-wash and yielded the largest increase in hemoglobin/hematocrit from pre- to post-wash.

The average pre-wash and post-wash values for each wash solution were compared using one-way analysis of variance (ANOVA).

RESULTS

Each wash solution was used for three separate wash cycles to increase the sample size to further determine which solution would give a physiological final autotransfusion product. There was no difference between the three wash solutions regarding the final glucose levels ($p = .36$) (Table 2). NS resulted in a significantly higher chloride level when compared with both Normosol®-R and Plasma-Lyte A (mean 134 vs. 87 and 89 mmol/L, respectively, $p < .001$). NS wash resulted in washing off most of the potassium with K value consistently <1 mmol/L ($p < .001$) in the final solution. Normosol®-R and Plasma-Lyte A produced potassium levels within the normal range for all wash cycles. As expected NS wash had the highest level of sodium

Table 1. Wash solutions.

	Electrolytes Added per 1 L		
	Normosol-R	Plasma-Lyte A	.9% NS
Osmolarity (mOsmol/L)	293	294	308
Sodium (mEq)	140	140	154
Chloride (mEq)	98	98	154
Potassium (mEq)	5	5	N/A
Magnesium (mEq)	3	3	N/A
Acetate (mEq)	27	27	N/A
pH	6.5–7.6	6.5–8.0	5.0 (4.5–7.0)

Table 2. Pre/post wash solution results.

	Normosol						Normal Saline						Plasmalyte					
	1st Wash		2nd Wash		3rd Wash		1st Wash		2nd Wash		3rd Wash		1st Wash		2nd Wash		3rd Wash	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Glucose (mg/dL)	151	47	169	57	180	71	185	64	191	78	185	81	184	61	183	55	208	85
Chloride (mmol/L)	97	87	98	88	99	88	137	133	137	133	139	137	99	89	99	90	99	89
Potassium (mmol/L)	10.8	5	11.8	5	12.5	5.1	9.7	<1	10.4	<1	10.2	<1	13.6	5.1	13.6	5.2	13.5	5.2
Sodium (mmol/L)	132	128	132	129	132	128	145	147	144	148	145	147	131	131	132	131	132	131
Phosphate (mg/dL)	2.8	2.1	2.9	1.4	3	1.2	3.4	2	3.4	1.4	3.3	1.1	3.8	3.2	3.7	2.4	3.8	1.5
Magnesium (mg/dL)	3.3	3.6	3.2	3.6	3.2	3.6	.3	.3	.3	.4	0.3	.4	3.1	3.7	3.1	3.7	3	3.7
Hemoglobin (Gm/dl)	7.4	14.6	7.6	14	7.5	14.7	6.9	15.6	6.3	14.7	6.2	15.3	6.1	16	6	16	6.5	15.8
Hematocrit (%)	24.5	47.2	24.8	45.4	24.4	47.1	23.1	51.3	21.2	48.6	20.9	50.7	19.8	50.3	19.9	51.1	21.2	50.5

Pre, pre-wash cycle; post, post-wash cycle.

after the wash compared with Plasma-Lyte A and Noromsol®-R (147 vs. 131 and 128 mmol/L, respectively, $p < .001$). There was no significant difference in the final phosphate levels after wash in all three solutions, where all pre-wash samples had a low phosphate levels and produced a decrease in post-wash samples for all three solutions ($p = .24$). Magnesium levels were noted to be elevated in all pre-wash samples for Normosol®-R and Plasma-Lyte A. Both solutions produced a slight increase in the post-wash samples. NS on the other hand produced a low level of magnesium pre-wash and post-wash. Please note that all wash solutions had calcium levels pre- and post-wash <1 mg/dL, therefore was not included in Table 2. As expected, all wash solutions produced an increase in the hemoglobin and hematocrit levels. Plasma-Lyte A produced the largest increase in hemoglobin, with post-wash averaging hemoglobin of 15.9 g/dL, compared with 14.4 and 15.2 g/dL for Normosol®-R and NS ($p = .005$). Plasma-Lyte A had a significantly higher post-wash hematocrit level when compared with Normosol®-R and NS (mean of 50.6% vs. 50.2% and 46.5%, respectively, $p = .005$)

DISCUSSION

The ability to reduce the demand for allogenic blood products during pediatric cardiothoracic surgery has always been a major challenge. The need for allogenic blood products continues to increase because of increasing acuity of illnesses, complexity of the procedures, associated comorbidities, and other compounding factors (6). The adverse effects of blood transfusion on morbidity and mortality, including the infection risk, increased hospital and intensive care length of stay, and associated cost, have been well documented (7–10). Autotransfusion has emerged as a standard of care for the pediatric patient population undergoing cardiac surgery utilizing CPB. Although the principle theory of cell saving and washing is the same, the process to achieve this varies from one device to another. This variation between the different types of cell saving technologies can also result in differences in the quality of the final autotransfusion product (11). The composition of the wash solution may play a major role in achieving a physiologically normal final autotransfusion product (5). This becomes very evident in the pediatric population with their notably smaller circulating blood volume. The need for large volumes of autotransfusion products may easily impact the patient's overall electrolyte balance. Previous studies have demonstrated alterations in the acid-base balance, electrolytes' composition, and hematocrit in the washed blood when NS was used as the wash solution (4,5). Hypernatremia is independently associated with intensive care unit mortality (12). Our data supports that when utilizing NS as a wash solution, the final autotransfusion product produces an increase in sodium and chloride levels. With that being said, if the goal is to wash an allogenic blood product before transfusion because of a high level of potassium noted in stored products, NS removed all potassium below <1 mmol/L. Plasma-Lyte A was noted to have a larger average increase in hemoglobin and hematocrit, with a more physiologically balanced final autotransfusion product than both NS and Normosol®-R.

A limitation of this study is the small sample size, but despite this, our data illustrate the potential advantages of Plasma-Lyte A and Normosol®-R as superior alternatives for an autotransfusion wash solution when compared with NS. A future direction could be a prospective randomized study comparing the potential clinical impact of each of these three wash solutions on patients' electrolytes after pediatric cardiac surgery that is associated with the use of cell saver blood transfusion.

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