

Case Report

Damaged Erythrocytes Following Cell Washing with a Hypotonic Solution: A Case Report

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ABSTRACT

This case report deals with the incidence of high levels of plasma free hemoglobin secondary to the infusion of erythrocytes washed with sterile water during an autotransfusion procedure. The danger of high levels of plasma free hemoglobin is acute renal failure due to precipitation of free hemoglobin in the form of acid hematin. Treatment attempts to prevent the precipitation by maintaining high urine output (75 - 100 ml/hr or 1-2 ml/kg/min) and alkalizing the urine (pH of 8). Preventative treatment is outlined and includes: fluid and colloid replacement; diuretics and sodium bicarbonate. In this case, acute renal failure was prevented and the patient was discharged on post operative day five.

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INTRODUCTION

The purpose of this case report is to discuss the clinical problem of increased plasma free hemoglobin levels secondary to the infusion of a damaged erythrocyte solution generated from an autotransfusion procedure. The red blood cell damage was osmotic in origin, following cell washing with sterile water instead of normal saline solution. The effects of high levels of plasma free hemoglobin have been well documented in journals and textbooks (1-3). Prompt diagnosis and treatment is key in preventing serious complications such as renal failure. A treatment protocol for increased plasma free hemoglobin is outlined later in this article.

CASE REPORT

The patient is a 60 year old, white male who experienced chest pain while walking up a hill, and reported to the emergency room of a local hospital.

Approximately 70 mg of tissue plasminogen activator was administered after a diagnostic electrocardiogram (ECG). Elevated CPK enzymes were also noted. Arrhythmias developed after thrombolytic therapy and were treated successfully with procainamide hydrochloride, lidocaine hydrochloride and metoprolol tartrate. Heparin and aspirin therapy were initiated as well. The patient's status stabilized, and he was transferred to the adult intensive care unit (AICU). Cardiac catheterization performed after the patient's status stabilized, revealed high grade lesions of the left anterior descending (LAD), first diagonal and right coronary artery (RCA).

The patient was transferred to University of Nebraska Medical Center one week postinfarction for cardiac revascularization. Bypass surgery utilizing systemic hypothermia (32°C) and sanguinous cardioplegia (retrograde and antegrade), was uneventful. Blood flows were maintained near a cardiac index of 2.4 L/min/m². Bypass time was 73 minutes with a cross clamp time of 50 minutes. The left internal mammary artery was used to graft the LAD and first diagonal and saphenous vein was used for the RCA.

While transferring the patient from the operating table to bed for transfer to AICU bright red urine was noted. The patient's urine was yellow and clear pre-operatively. After a brief investigation, it was discovered that a three liter bag of sterile water was used to wash the centrifuged erythrocytes. This was done for three bowls (225 ml each), which were each washed with 1000 ml of sterile water. Approximately 200-250 ml of this water and erythrocyte slurry was administered to the patient. The patient was transferred to the AICU with stable vital signs and bright red urine. Treatment of the hemoglobinuria was initiated at once and continued through post operative day one, and the urine became clearer and pale tea colored by 2100 of the operative day. Urine output (Table 1) and alkalinity were maintained with albumin, crystalloid, mannitol, furosemide and sodium bicarbonate (Table 2). By post-operative day two the urine was quite clear and orders

Table 1
Urine Output Data
Urine output is in milliliters

DAY	TIME	OUTPUT (ml)
OR DAY	0600-1400	1430
	1400-2200	1250
	2200-0600	2870
POST-OP DAY #1	0600-1400	3110
	1400-2200	1620
	2200-0600	1570
POST-OP DAY #2	0600-1400	1420
	1400-2200	0830
	2200-0600	1370

for transfer out of AICU were written. Pertinent lab values (Table 3) were also monitored through discharge which was made on post-operative day five. The patient was discharged home on the following medications: famotidine, metoprolol tartrate, ducosate sodium, aspirin and propoxyphene napsylate with acetaminophen.

DISCUSSION

The infusion of a damaged erythrocyte slurry, containing high levels of free hemoglobin, may be considered a type of acute hemolytic transfusion reaction resulting in high levels of plasma free hemoglobin (1,2). This particular case is not a true hemolytic transfusion reaction, which may produce the following signs and symptoms resulting from reactions to immunogenic proteins: fever, chills, chest pain, nausea, dyspnea, lumbar or flank pain, feeling of impending doom, hypotension, tachycardia, diffuse bleeding/disseminated intravascular coagulopathy (DIC), and hemoglobinuria (2-6). Most of these findings are masked by general anesthetics except hypotension, tachycardia, bleeding, and hemoglobinuria (3,4). Hemoglobinuria was the first indication of a hemolytic type reaction in this case.

With the bathing of red blood cells in a hypotonic solution, such as sterile water, the intracellular fluid volume increases by 60% to 70% as water follows the osmotic gradient (7). Erythrocytes immediately swell to a spherical shape instead of their normal biconcave disc (7). As intracellular tension increases, the cell membrane becomes more permeable and allows cellular constituents to leak into the surrounding hypotonic solution so an osmotic equilibrium can be attained (7). The erythrocyte may resume its normal shape when returned to an isotonic environment, but the intracellular constituents are markedly different (7). The presence of free hemoglobin in the plasma is a potentially dangerous state. Plasma free hemoglobin in the form of acid hematin circulates in the blood and may precipitate in the distal tubules of the kidneys, causing mechanical blockage which may

Table 2
Treatment Regimen

DAY	TIME	ALBUMIN	MANNITOL	FUROSEMIDE	NaHCO ₃	KCl
OR DAY	1200	250ml 5%	25 g	-	100 mEq	40 mEq
	1830	500ml 5%	25 g	100 mg	100 mEq	20 mEq
	2130	500ml 5%	25 g	100 mg	100 mEq	-
POST OP DAY #1	0100	500ml 5%	-	-	100 mEq	-
	0400	100ml 25%	-	80 mg	-	-
	1300	-	-	-	-	20 mEq
	1900	-	-	80 mg	-	-

Table 3
Patient Lab Values

Pla Hgb = plasma free hemoglobin in mg/dL, Ur Hgb = urine hemoglobin presence, HCT = hematocrit in percent, Na = serum sodium in mEq/L, K = serum potassium in mEq/L, Cl = serum chloride in mEq/L, BUN = blood urea nitrogen in mg/dl, CREAT = serum creatinine in mg/dl, PLT = platelet count in 1000s of platelets per microliter, pH = arterial blood pH, BICARB = arterial bicarbonate levels in mEq/L.

	Pla HGB	Ur HGB	HCT	Na	K	Cl	BUN	CREAT	PLT	pH	BICARB
Baseline	*	*	43	137	4.3	100	16	1.2	102	7.41	27
OR DAY											
1200	600	+	29.1	134	3.8	101	16	1.1	216	7.51	24
1600		-	30.5						247	7.39	27
2000		+	31.0		4.6					7.46	29
POST-OP DAY 1											
0000		-	30.8		4.5				252	7.48	33
0400		-	26.9	140	3.6	92	32	1.6	219	7.46	39
0800		-	27.8		4.1					7.46	38
1200			26.3		3.9					7.45	34
1600			26.0		4.0					7.43	37
2000	NO LABS DONE										
POST-OP DAY 2											
0000			27.9		4.0					7.44	34
0400			28.1	136	4.0	94	26	1.2	204	7.41	30

lead to renal failure (2-4,7,8). In order to decrease precipitation, high urine output and elevated urine pH must be maintained (2-4,7,8). Failure to properly identify and treat this condition may result in acute renal failure which could be fatal in as little as one week (2,3). Small concentrations of plasma free hemoglobin do not always induce acute renal failure (2,4). The body can absorb a fair amount of plasma free hemoglobin without spilling it into the urine, producing hemoglobinuria (2-4). For comparison, plasma with a free hemoglobin of 2 mg/dL is a very faint pink (2-4). If that concentration were raised to 100 mg/dL, the plasma would appear quite red (2-4). When a 150 mg/dL concentration is reached, hemoglobinuria occurs as hemoglobin is filtered into the urine (2-4). Besides being filtered by the kidneys, plasma free hemoglobin is bound to circulating plasma protein, haptoglobin (2-4). This complex is then eliminated by the reticulo-endothelial system and concentrations of 100 mg/dL of free hemoglobin may be accommodated (3,4).

Treatment of hemoglobinuria attempts to increase urine flow and increase urine pH, thus decreasing the precipitation of the haptoglobin-acid hematin complex in the distal tubules (2-4,8,9). Following is a list of therapies to consider in case of acute hemolytic transfusion reaction which has been adapted from Miller, Van Erdewyk and others (2-6,8,9).

- 1) Stop transfusion
- 2) Treat hypotension
 - a) Crystalloid
 - b) Dopamine (also to increase renal perfusion)
 - c) Other blood if needed
- 3) Maintain adequate urine output (75-100 ml/hr or 1-2 ml/kg/hr)
 - a) Mannitol 12.5-50 g over 5-15 minutes IV
 - b) IV fluids to maintain hydration
 - c) Furosemide 20-40 mg IV
 - d) Albumin (250 ml-5% or 50 ml-25%) as plasma volume expander
- 4) Increase urine pH to 8
 - a) Sodium bicarbonate 40-70 mEq/70 Kg and repeat urine pH every two hours
- 5) Monitor patient plasma and urine hemoglobin concentrations as well as fibrinogen, fibrin split products, platelet count, activated partial thromboplastin time, and serum haptoglobin if DIC is suspected

Fortunately, patient outcome was not affected negatively in this case and the patient was discharged on the fifth postoperative day. Urine output was well maintained and cleared quickly while using the treatment regimen listed in Table 2 through post operative day one. Although not all therapies previously mentioned were used, those used were quite effective for this patient.

The problem of hanging the wrong IV solution or administering the wrong drug is not new in health care despite careful review prior to administration. This particular mistake was dichotomous in nature, and resulted in a learning experience for

all involved. The manner in which the irrigation solutions are stored and restocked needs modification. The different solutions (glycine 1.5%, saline .9% & 3%, and sterile water) are stored on a cart in the O.R. area. The sterile water was pulled off the shelf which was designated for normal saline. There have been multiple instances in which the wrong solutions have been stocked on the wrong shelf and nearly used in place of the ordered solution. In order to assure this error does not happen again, a separate supply of normal saline is maintained by the perfusion team in an area away from other irrigation solutions and near the autotransfusion disposables. This allows for an extra person to check the solution before utilization. The second mistake was the hanging and using of the sterile water to wash the erythrocytes. This error would seem to be easy to correct, but maintaining the accuracy of solutions used is a daily duty. This duty can be complicated by emergencies, training of new personnel or students, and multiple persons assigned to the same task. On the pre-bypass check list, the readiness of the autotransfusion device is addressed. When checking this criteria, the wash solution is scrutinized to validate its accuracy. All faculty were informed of the error and reminded to insure the accuracy of all solutions and medications to be administered. The error made and the treatment protocol were then discussed during a weekly morbidity and mortality conference. This served to reinforce the importance of thoroughness and accuracy in all procedures, even the seemingly uncomplicated ones, such as autotransfusion. No further related errors have been discovered.

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