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CASE REPORT

Warning about potential incidents of critical hyperkalemia during massive transfusion protocol after the preservation period of red blood cell products was extended in Japan

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Abstract

Background: Recently, the Japanese Red Cross Society approved extension of the preservation period of red blood cell products. Since then, we have already experienced two cases of critical hyperkalemia during massive transfusion protocol (MTP).

Case Presentation: Case 1, a 24-year-old man was stabbed in his right posterior chest. Although quick hemorrhage control was completed 35 min after arrival, his potassium level increased from 3.5 to 8.9 mEq/L within 40 min. Case 2, a 44-year-old man was transferred to our hospital after a car hit him. We immediately started resuscitation including MTP and opened his abdomen 24 min after arrival. His potassium level increased from 3.5 to 7.8 mEq/L within 38 min.

Conclusion: Although several other factors might be causing this rise in potassium, we consider the extended preservation periods of red blood cell products to be one cause of these unexpectedly rapid rises in potassium during MTP.

KEYWORDS
hyperkalemia, hyperpotassemia, massive transfusion protocol, red blood cell products

BACKGROUND

Recently, the Japanese Red Cross Society issued a notice of their approval to extend the preservation period of red blood cell (RBC) products.[1] This extension is, of course, evidence based and mainly promulgated to reduce costs and avoid the destruction of limited resources. However, when massive transfusions are administered under the massive transfusion protocol (MTP) to treat patients, the incidences of adverse events related to this change are not well known. Here, we emergently report our experiences with two cases of critical hyperkalemia during trauma resuscitation with MTP that, to our knowledge, have never been reported before.

CASE PRESENTATION

Case 1

A 24-year-old Asian man was transferred to hospital after having been stabbed in his right posterior chest by a housemate. On hospital arrival, the patient's airway was maintained spontaneously, respiratory rate was 30 bpm, blood pressure was unmeasurable, but the femoral artery pulse was palpable, heart rate was regular at 136 bpm, body temperature was 36.1°C, and Glasgow Coma Scale was E3V1M5. After we found a massive hemopneumothorax on his right-side chest via focused assessment with sonography for trauma (FAST) within 3 min after his arrival, we immediately performed tube thoracostomy and activated MTP with the use of O+

RBCs. During surgery, which started 17 min after arrival, we found a penetrating injury proximal to the inferior lobe of the liver and rapidly performed non-segmental lobectomy under the use of a hilar clamp. However, although quick hemorrhage control had been obtained within 35 min after patient arrival, he went into ventricular fibrillation during the surgery, and we found that his potassium level had increased from 3.5 to 8.9 mEq/L within 40 min (Table 1). The amount of blood products used at this time were RBCs (O+), 8 units; fresh frozen plasma (FFP), 12 units; and platelet concentrate (PC), 10 units. The patient could not be resuscitated even with the full use of considerable resuscitative options.

Case 2

A 44-year-old Asian man was transferred to our hospital after being hit by a car while riding his bicycle. On hospital arrival, the patient's airway was maintained spontaneously, respiratory rate was 30 bpm, blood pressure was 98/87 mm Hg with a palpable left femoral artery pulse, heart rate was regular at 138 beats/min, body temperature was 36.1°C, and Glasgow Coma Scale was E1V1M2. We found a left pneumothorax and fluid collection at Morison fossa and the perispleen area and started blood transfusion with activation of the MTP. Because the patient's hemodynamics completely collapsed, left tube thoracostomy was immediately performed, and we prepared to open the patient's abdomen in the resuscitation unit. During the preparations for surgery, as we also obtained radiological information about a concomitant severe pelvic fracture, we initiated resuscitative endovascular balloon occlusion of the aorta, but did not inflate the balloon. The patient's abdomen was opened 24 min after arrival. The operative findings were minor liver laceration, intra-mesenteric hematoma, small bowel perforation, and minor splenic injury. We focused on hemorrhage control with perihepatic and splenic packing and ligation of the mesenteric vessels and also minimized contamination and followed a damage control strategy. However, once the patient's hemodynamics appeared to stabilize after the 20 min surgery, he suddenly went into ventricular fibrillation, where we found that his potassium level had increased from 3.5 to 7.8 mEq/L within 38 min after administering the initial blood transfusion (Table 2). The amount of blood products delivered at this time were RBCs (O+), 12 units; FFP, 12 units; and PC, 20 units. Although the patient was returned to spontaneous circulation and subsequently underwent an interventional radiology procedure, he died from massive multifocal bleeding because of subsequent coagulopathy.

DISCUSSION

Although several factors might be causing in hyperkalemia, these two patients had no other considerable factors such as past kidney disease, current rhabdomyolysis caused by crush syndrome, or any other possible injuries. Furthermore, there were no additional laboratory findings such as irregular anti-bodies.

MTP is already globally well known one as of the main procedures for achieving success in trauma resuscitation.[2–4] Recently, although several protocols for the guidance of massive blood transfusion such as goal-directed transfusion by using thrombo-elastography[5] have been proposed, we traditionally assume that most of the high-level trauma care centers, including ours, follow the RBC:FFP:PC = 1:1:1 ratio theory based on the previous evidence.[6–8]

In our institution, MTP including cryoprecipitate is always available, and once activated, packages are constantly brought to the resuscitation unit to maintain the ratio of composition as shown in Figure 1. We also usually

TABLE 1 Atrial blood gas analysis data on admission and just the time ventricular fibrillation was detected 40 min after administration of blood transfusion in patient 1.

Analyzed items	On admission	40 min after administration of blood transfusion
pH	7.37	7.14
PaO_2 (mm Hg)	213	79.6
$PaCO_2$ (mm Hg)	38.8	42.1
HCO_3^- (mmol/L)	21.9	13.9
Base excess	−2.5	−13.3
Na^+ (mEq/L)	140	128
K^+ (mEq/L)	3.5	8.9
Cl^- (mEq/L)	107	107
Ca^{2++} (mEq/L)	1.16	0.87
Cr^+ (mg/dL)	0.82	0.58
Lactate level (mmol/L)	3.5	6.4

TABLE 2 Atrial blood gas analysis data on admission and just the time ventricular fibrillation was detected 38 min after administration of blood transfusion in patient 2.

Analyzed items	On admission	38 min after administration of blood transfusion
pH	7.17	7.14
PaO_2 (mm Hg)	454	382
$PaCO_2$ (mm Hg)	51.1	33.2
HCO_3^- (mmol/L)	20.9	10.9
Base excess	−6.3	−16.4
Na^+ (mEq/L)	142	130
K^+ (mEq/L)	3.5	7.8
Cl^- (mEq/L)	107	105
Ca^{2++} (mEq/L)	1.22	0.53
Cr^+ (mg/dL)	1.40	1.23
Lactate level (mmol/L)	7.0	8.3

	Pack 1	Pack 2	Pack 3	Pack 4	Pack 5	Pack 6	Pack 7
RBC	O(+) 10u	Homogeneous 6u	Homogeneous 6u	Homogeneous 6u	Homogeneous 6u	Homogeneous 6u	Homogeneous 6u
FFP	Cryoprecipitate AB(+) 12u	Homogeneous 6u	Homogeneous 6u	Homogeneous 6u	Homogeneous 6u	Homogeneous 6u	Homogeneous 6u
PC		Homogeneous or AB(+) 20u			Homogeneous or AB(+) 20u		

FIGURE 1 Our massive transfusion protocol including cryoprecipitate based on the RBC:FFP:PC = 1:1:1 ratio theory. Once activated, packages are constantly brought to the resuscitation unit while maintaining the same ratio of composition. FFP, fresh frozen plasma; PC, platelet concentrate; RBC, red blood cells.

use calcium chloride 20 mEq (1 mEq/mL) approximately every 30 to 60 min interval under the results of blood gas analysis.

We usually administer blood transfusion with the use of a Level 1 Fast Flow Fluid Warming System (Smiths Medical ASD, Minneapolis, MN) from the peripheral vein via a 20-gauge or larger size needle. We consider this is also one of the possible causes of hyperkalemia as it's physical pressure leads the RBC to hemolysis.

In 2023, the Japanese Red Cross Society issued a notice of their approval from the nation to extend the preservation period of RBC products.[1] Since then, the validity period of RBC products has been prolonged from 21 to 28 days after the blood has been drawn. Previously, the Japanese Red Cross Society had published in their guidelines that the potassium concentration in RBC products after the blood has been drawn is 36.3 ± 4.8 mEq/L at 7 days and that it increases to 60.3 ± 4.6 mEq/L in 28 days.[9]

To combat this problem, we currently can only check blood gas values constantly at ~15- to 30-min intervals, use a calcium chloride preparation more frequently, and prepare washed RBC products if available. The option to use a potassium adsorption filter is also available, but the filter needs to be exchanged at an interval of every 4 units delivered according to the manufacturer's documentation. Although it was difficult to retroactively verify the exact expiration dates of the blood products used in these two cases, these blood products could have been hyperkalemic.

CONCLUSION

We experienced two cases of critical hyperkalemia during MTP after the allowance to extend the preservation periods of RBC products was granted. Although there might be several other factors involved in the increase of potassium in these patients, we consider it extremely important to report these unexpectedly rapid increases in potassium levels during MTP to those who perform MTP with the use of current RBC products in Japan.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

Data sharing not applicable to this article as no datasets were generated or analyzed during the current study.

ETHICS STATEMENT

Approval of the research protocol: N/A.
Informed consent: Witten informed consent was obtained from the patient for publication of this case report and accompanying data.
Registry and the registration no. of the study/trial: N/A.
Animal studies: N/A.

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