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CASE REPORT

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Survival of a hemodynamically unstable pediatric liver trauma patient with aortic balloon occlusion catheter during air transport: A case report

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Abstract

Background: The utility of resuscitative endovascular balloon occlusion of the aorta (REBOA) in children remains unclear.

Case Presentation: An 11-year-old patient with liver trauma with massive extravasation was transported to a local hospital, where an emergency trauma surgery was unavailable. Following the placement of REBOA as a bridge to hemostasis, she was transferred to our hospital by a firefighting helicopter with balloon occlusion. Immediately, she underwent damage control laparotomy and transcatheter arterial embolization. She was subsequently discharged from the hospital 6 months after the accident without complications.

Conclusion: REBOA as a bridge to hemostasis may be useful for pediatric patients.

KEYWORDS

air transport, pediatric REBOA, pediatric trauma, REBOA, resuscitative endovascular balloon occlusion of the aorta

INTRODUCTION

Resuscitative endovascular balloon occlusion of the aorta (REBOA) has received a great deal of attention in adult trauma and non-trauma settings. However, its utility in children is unclear.[1] Although there have been studies of REBOA in children over 16 years of age, few in children under 16 years exist.[2,3] We describe an 11-year-old patient with liver trauma undergoing REBOA inflation during air transportation as a bridge to hemostasis.

CASE PRESENTATION

A previously healthy 11-year-old girl (weight 30 kg and height 143 cm) was transported to a local hospital following a road traffic accident. On arrival, Glasgow Coma Scale (GCS), systolic blood pressure (sBP), heart rate (HR), respiratory rate (RR), and body temperature (BT) were E4V4M6, 103 mmHg, 113/min, 30/min, and 36.3°C, respectively. Focused assessment with sonography for trauma revealed perisplenic echo-free space. Contrast-enhanced computed tomography (CECT) revealed grade V liver laceration (American Association for the Surgery of Trauma Organ Injury Scale) with massive intraperitoneal contrast extravasation (Figure 1). An emergency trauma surgery was unavailable at the local hospital. Therefore, the patient was transported after undergoing REBOA inflation to our hospital by a firefighting helicopter. Rescue Balloon® (Tokai Medical Products, Inc., Aichi, Japan) was inserted into the left femoral artery and placed in the thoracic descending aorta (zone 1).[4] REBOA inflation of 20 mL elevated sBP to approximately 160 mmHg; REBOA was deflated to 15 mL. REBOA deflation before transport reduced sBP to approximately 90 mmHg; REBOA was inflated 15 mL during transport.

On arrival at our hospital, GCS, sBP, HR, RR, and BT were E4V4M6, 145 mmHg, 136/min, 26/min, and 34.4°C, respectively. REBOA deflation after arrival reduced sBP to 98 mmHg and elevated HR. REBOA was inflated again. Immediately, the patient underwent damage control laparotomy, which revealed 1000 mL of intraperitoned hemorrhage due to complex liver laceration in the right lobe without active bleeding under balloon occlusion. REBOA deflation was performed after portal triad clamping. Complete hemostasis was achieved by following perihepatic packing and transcatheter arterial embolization of the right hepatic artery. The vital signs, REBOA inflation volume, transfusion volume, arterial blood gas, and procedures performed before intensive care unit admission are shown in Figure 2. She underwent hepatic suturing and omental packing for the liver laceration at a second-look laparotomy on the following day (Figure 3). The injury severity score (ISS) was 34, the revised trauma score was 7.55, and the probability of survival was 0.94 in this case.

Postoperatively, serum aspartate aminotransferase and alanine aminotransferase levels were elevated to a maximum of 2270 and 1144 IU/L, respectively, on day 3. Serum creatinine and blood urea nitrogen levels were elevated to

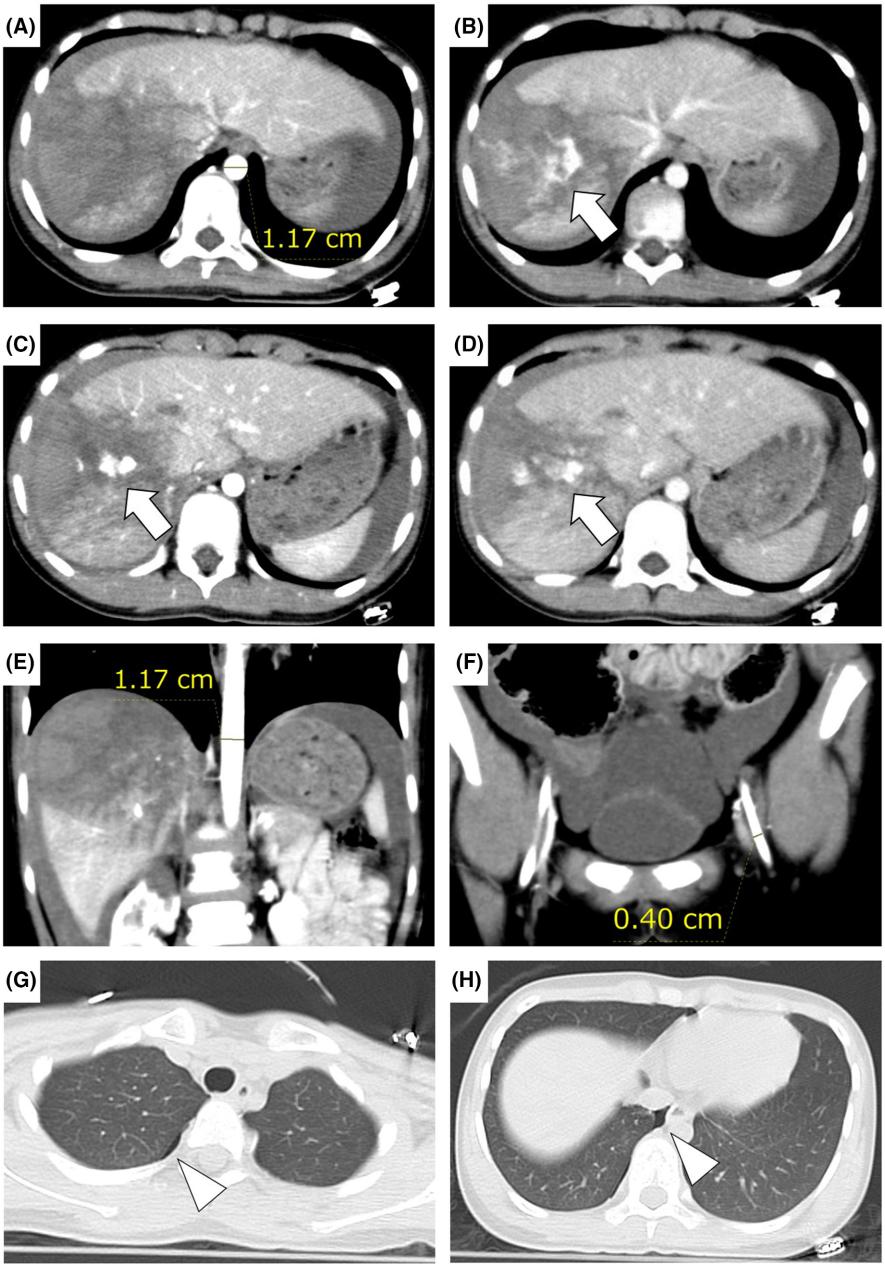
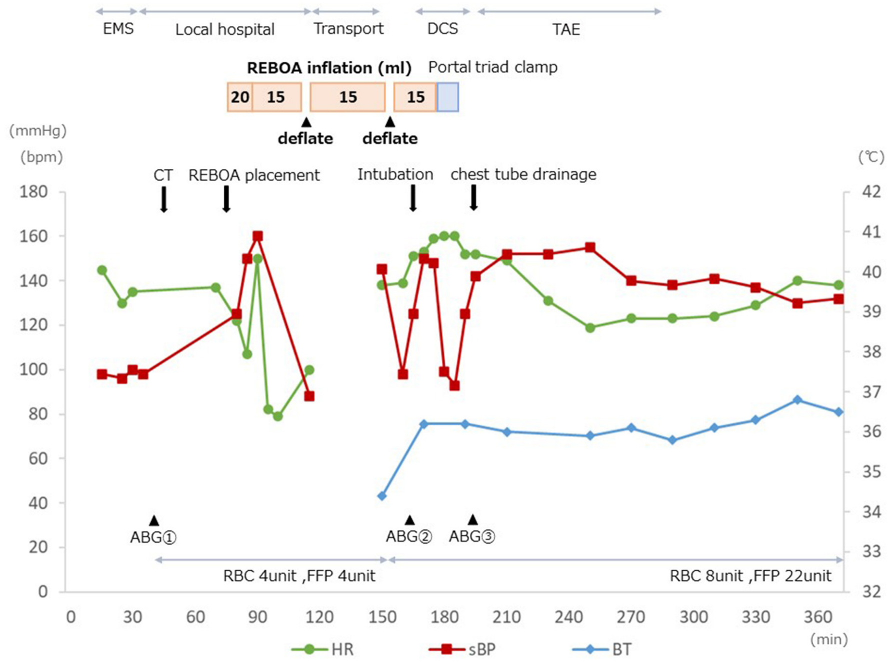


FIGURE 1 A contrast-enhanced computed tomography scan at the local hospital. (A, C) Arterial phase axial images. (B, D) Venous phase axial images. Computed tomography images revealed the massive contrast extravasation in the liver from the arterial phase to the equilibrium phase (white arrows). (E, F) Arterial phase coronal images. Computed tomography images show the thoracic descending aortic and left common femoral aortic diameters. (G, H) Chest computed tomography images show minor right pneumothorax (white arrowheads).



ABG①	
pH	7.398
PCO^2	27.0 mmHg
PO_2	122.0 mmHg
HCO_3^-	16.3 mEq/l
BE	-7.0 mEq/l
Lac	5.1 mmol/L

ABG②	
pH	7.080
PCO^2	43.7 mmHg
PO_2	120.0 mmHg
HCO_3^-	11.9 mEq/l
BE	-15.7 mEq/l
Lac	10.9 mmol/L

ABG③	
pH	6.928
PCO^2	78.3 mmHg
PO_2	332.0 mmHg
HCO_3^-	12.0 mEq/l
BE	-15.0 mEq/l
Lac	11.7 mmol/L

FIGURE 2 A progression chart from the patient's transportation to the local hospital after the injury to her transportation to our hospital for treatment. ABG, arterial blood gas; BT, body temperature; CT, computed tomography; DCS, damage control surgery; EMS, emergency medical service; FFP, fresh frozen plasma; HR, heart rate; RBC, red blood cells; REBOA, resuscitative endovascular balloon occlusion of the aorta; sBP, systolic blood pressure; TAE, transcatheter arterial embolization.

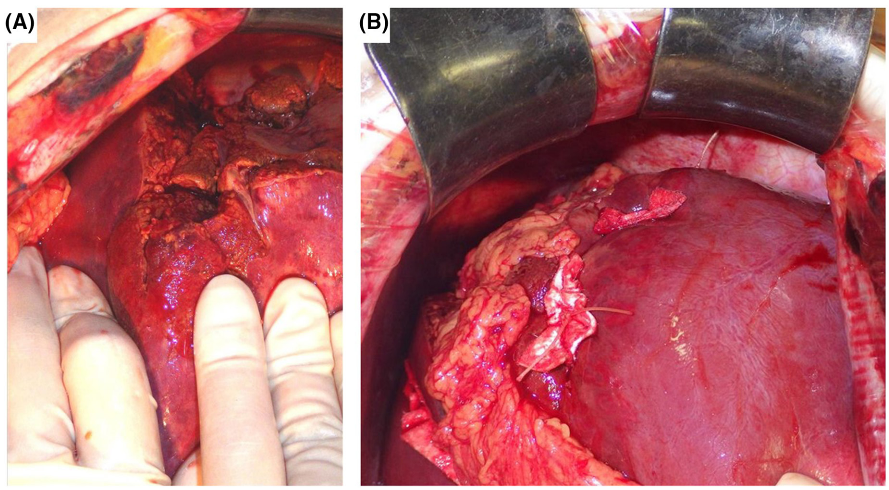


FIGURE 3 Surgical images of the liver in our hospital. (A) The image demonstrating complex liver laceration in the right lobe. (B) The image demonstrating the liver after hepatic suturing and omental packing.

a maximum of 4.78 and 86 mg/dL, respectively, on day 5. After a month, the blood tests were normal. Six months after the accident, she was discharged from the hospital without organ failure.

DISCUSSION

The utility of REBOA in children is unclear.[1] A study using the Japan Trauma Data Bank revealed high ISS and survival rates in pediatric patients mainly aged over 16 years undergoing REBOA inflation, similar to those in adults.[2] A registry analysis in the United States revealed hemodynamic improvement in pediatric patients aged over 16 years with trauma undergoing REBOA inflation.[3] However, few studies mentioned the utility of REBOA inflation in pediatric patients with trauma under 16 years of age. In pediatric trauma, hemorrhage is rare and need for emergent hemorrhagic control is even rarer. On the other hand, hemorrhage was the most common cause of potentially preventable pediatric trauma deaths.[5] REBOA, a minimally invasive method for temporary hemorrhage control, may play a role in reducing the number of pediatric trauma deaths.[3] In this case, emergency trauma surgery was unavailable at the local hospital. Therefore, the 11-year-old patient with massive extravasation was transported after undergoing REBOA inflation to our hospital and saved. REBOA as a bridge to hemostasis may be useful for pediatric patients.

We should consider several complications of pediatric REBOA. First, children are at high risk of vascular complications compared with adults. A study found an increased risk of ipsilateral pulseless extremity when the outer diameter of the catheter exceeds 50% of the vessel lumen.[6] A common femoral artery diameter of 5.9 mm is the minimum size that would permit the use of 7-French sheath of REBOA. Current REBOA devices are designed for adult use and the manufacturer does not recommend REBOA for aortas less than 15 mm in diameter.[2] In this case, the left common femoral artery diameter was 4 mm, and the descending thoracic aortic diameter was approximately 12 mm, measured by CECT (Figure 1). No complications were observed. A 4-French sheath of REBOA may be better to reduce vascular complications in pediatric patients compared with a 7-French sheath.[7]

Second, we should consider ischemia–reperfusion injury associated with prolonged blood flow occlusion. A study revealed that 60 min of zone 1 REBOA may result in irreversible organ injury and death using pediatric swine.[8] If a pediatric patient requires immediate massive hemorrhage control, complete zone 1 REBOA for less than 30 min is useful as a bridge to hemostasis without complications.[8] An animal study reported the utility of partial REBOA in active hemorrhage.[9] Partial REBOA maintained normal physiology better than did complete REBOA, minimizing systemic impact of distal organ ischemia, reducing hemodynamic instability, and potentially allowing for longer periods of intervention.[9] The balloon at partial REBOA should be inflated in correspondence to titrating the proximal blood pressure to approximately 80–90 mmHg while monitoring distal blood pressure to support distal perfusion.[10] In this case, the balloon volume of REBOA was not adjusted during transport. To reduce complications, she should have undergone partial REBOA. The vessel size in children is smaller than that in adults, since slight balloon volume adjustment results in large changes in flow rate, careful attention should be paid.[1] It is more important to measure blood pressure proximal and distal to balloon occlusion using pediatric partial REBOA.

CONCLUSION

REBOA as a bridge to hemostasis may be useful for pediatric patients. However, we should be aware of the complications of pediatric REBOA.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

ETHICS STATEMENT

Approval of the research protocol: N/A.
Informed consent: Informed consent for publication was obtained from the patient's family.
Registry and registration no. of the study/trial: N/A.
Animal studies: N/A.

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