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Consideration of Anesthesia Management for Emergency Surgery with Resuscitative Endvascular Balloon Occlusion of the Aorta (REBOA) Inserted

Hirokazu Muneishi

Sugita Genpaku Memoriakl Obama Municipal Hospital, Japan

Abstract

Resuscitative endvascular balloon occlusion of the aorta (REBOA) is used to maintain cerebral blood flow and coronary artery blood flow in the case of uncontrollable massive intraperitoneal and retroperitoneal hemorrhage until definitive hemostasis is performed. It is considered useful as a treatment. In radical emergency surgery when REBOA is inserted, special consideration must be given to anesthesia management and organ blood flow. We have experienced a case in which a REBOA was inserted into a trauma patient in the emergency room (ER) and an emergency operation was performed, in which the patient's life was saved and a case in which the postoperative prognosis was poor, so we will discuss intraoperative management.

Keywords: REBOA, massive hemmorrhage, trauma

Introduction

Hemorrhagic shock leads to hypotension, cellular ischemia due to tissue hypoperfusion, reperfusion injury, and release of inflammatory mediators, ultimately resulting in DIC, multiple organ failure, and death.

The three symptoms of traumatic death are well-known hypothermia, coagulopathy, and acidosis, and treatment is first to control bleeding, and resuscitation aims to improve the above three in addition to increasing circulating blood volume.

Bleeding control begins with compression hemostasis, transcatheter arterial embolization (TAE), supplementation of the coagulation system with platelets and FFP, and administration of antithrombotic drugs such as tranexamic acid. If the patient does not respond to the above treatments, emergency surgery is required. At that time, an aortic clamp or REBOA may be inserted as a bridge control for uncontrollable bleeding from the ER or catheterization room.

REBOA is indicated for massive intra-abdominal bleeding associated with trauma, retroperitoneal bleeding associated with pelvic fracture, endogenous intra- and retroperitoneal bleeding, gastrointestinal bleeding, oxidative crisis bleeding, massive bleeding during pelvic tumor surgery, and abdominal Examples include ruptured aortic aneurysm.

At our hospital, REBOA is inserted in the ER for hemorrhagic shock that does not respond to fluid transfusion strategies. Although there are many reports of the effectiveness of REBOA insertion and radical surgery, there are few reports regarding anesthesia management during surgery. The REBOA inserted in the ER is

Organ ischemia can easily occur if the anesthesiologist does not know the time of inflate. Therefore, we reviewed and discussed the anesthesia management of emergency surgery cases using REBOA at our hospital.

Case

①Patient: 66 years old, male, height 163.7cm, weight 62.1kg

Past medical history: Nothing special

History of current illness: Injured in a car accident during an encounter. She was in a state of shock when the emergency services came in contact with her. Even after arriving at the ER, the radial artery palpation was weak and FAST positive.

Blood pressure tended to increase with infusion of Ringer's bicarbonate solution and Ringer's acetate solution . Whole body CT showed intraperitoneal hemorrhage and free air, and mesenteric damage with extravasation was observed. A fracture of the right iliac bone and an open fracture of the right tibial tuberosity were also observed, but the bleeding was not in the ear, and the main cause of shock was determined to be intra-abdominal bleeding. During X-rays of the right lower leg, the reaction gradually became dull, and blood transfusion (RCC, FFP) pumping was started. Since the patient could not get out of shock, Ketaral and fentanyl were administered and the trachea was intubated. REBOA was inserted from the right femoral artery (ZONE 2) and inflated with 25 ml of physiological saline. As a result, blood pressure increased from systolic 50 mmHg to 120 mmHg. The surgeon scheduled a trial laparotomy for traumatic sigmoid colon perforation and sigmoid colon mesentery injury, and orthopedic surgery to clean and suture the right lower leg. In the ER, 1500 ml of extracellular fluid and 4 units of concentrated red blood cell fluid (RCC) (type O emergency) were administered.

Surgery: PS4E, vital signs upon admission were GCS3 (E1VTM1), blood pressure 123/75, HR115, SpO2100. The routes were 20G and 18G lines in the left hand, 22G lines in the right hand, and 22G lines were inserted from the right radial artery.

Anesthesia was balanced with oxygen 1l/min, air 2l/min, desflurane 4%, remifentanil (0.05-0.2μg/kg/min), rocuronium, and fentanyl. Arterial blood gases at the start of surgery were FiO2 0.4, pH 7.115, pCO2 39.4 mmHg, pO2 157 mmHg, Hb8.6, Ht26.8, HCO3-12.1, BE-16, Glu352, Lac92. Appropriate administration of meiron and insulin for acidosis and hyperglycemia. At this point in the record, 57 minutes had passed since REBOA was inserted. 28 minutes after entering the room, the bleeding was not controlled, but when we fully deflated the REBOA in consideration of organ perfusion, it decreased from 100/63 mmHg to 61/45 mmHg, and we performed another inflate with 25 ml of physiological saline. Repeated administration of phenylephrine at 100 μg and norepinephrine at 0.2 μg/kg/min were started to reduce blood pressure. When the specimen was removed and the blood pressure was under control, a half deflate was performed, and a full deflate was performed while monitoring the blood pressure, and the blood pressure decreased again to 48/29, so a half

deflate was performed. After approximately 50 minutes, it was determined that a sufficient amount of fluid and blood transfusion had been administered and hemostasis had been controlled, and the patient was fully deflated. Blood pressure was stable at around 120/60 mmHg. However, it was difficult to withdraw from the continuous administration of noradrenaline, and a central venous catheter (double lumen) was inserted through the right internal vein. The blood pressure was adjusted to 0.15-0.3 μg/kg/min while monitoring blood pressure.

Before the first deflate, 500 ml of external fluid, 500 ml of HES preparation, and 2 units of RCC were administered. Furthermore, 1700 ml of external fluid, 250 ml of 5% albumin preparation, 8 units of RCC, and 2 units of FFP were administered to bring the patient to half and full deflate. Furthermore, blood pressure was unstable during the surgery, and 3,400 ml of external fluid, 500 ml of 5% albumin, 1,000 ml of HS preparation, 8 units of RCC, and 14 units of FFP were required to be administered by the end of the surgery. The amount of intraoperative blood loss was 2290ml. The surgery involved Hartmann technique, irrigation and osteosynthesis for the right lower leg fracture.

The patient was admitted to the ICU while being intubated postoperatively while receiving propofol and fentanyl. Arterial gas data at admission were FiO2 0.4, pH7.34 , pCO247.3mmHg, pO2284mmHg, Hb8.4, Ht22.4, HCO3-24.9, BE-0.4, Glu82, Lac43.

Postoperative course: The patient was extubated 2 days after surgery and transferred to the general ward 3 days after surgery. Postoperatively, paralytic intestinal obstruction occurred, but his general condition was stable and he was transferred to another hospital for rehabilitation.

②Patient: 20 years old, male, height 162cm, weight 48kg

Past medical history: Nothing special

History of present illness: Injured in an accident between two cars at an intersection. When the emergency services contacted him, he was complaining of severe pain in his abdomen. Upon arrival at the ER, blood pressure was 130/70 mmHg, heart rate was 105 bpm, GCS was 12 (E2V4M6), FAST was positive (there was echo-free space around the liver and bladder), and a contrast-enhanced CT scan was performed, indicating traumatic liver injury, while administering 2

units of RCC blood transfusion. TAE was performed and the patient was admitted to the ICU.

In the ICU, the patient became restless and had severe tachypnea, and blood pressure stabilized when fluids were loaded, but after the loading was finished, blood pressure decreased and tachycardia occurred. Two routes were secured at 16G and noradrenaline was started. Arterial blood gas analysis showed a drop in Hb from the 10s to 8s, suggesting portal or venous bleeding, and the systolic blood pressure dropped to 50-60mmHg, so REBOA was inserted through the left femoral artery (ZONE 1). Inflate 20ml of physiological saline to raise systolic blood pressure to around 140mmHg, perform partial deflation (3-10ml each) every 10 minutes, and stabilize blood pressure with partial inflate of 3ml of physiological saline 30 minutes after full deflation.

Entered the operating room for emergency damage control surgery. At this time, 1500 ml of extracellular fluid and 2 units of RCC were administered in the ICU.

Surgery: PS4E, vitals upon admission were BP 122/79mmHg, heart rate 102bpm, SpO2 97%. Anesthesia was rapidly induced with Ketaral 100 mg, remifentanil 0.1 μg/kg/min, rocuronium 70 mg, and norepinephrine 0.04 μg/kg/min, and the patient was intubated. Anesthesia was maintained using balanced anesthesia with oxygen 1l/min, air 2l/min, sevoflurane 1-1.5%, remifentanil 0.1-0.3μg/kg/min, fentanyl, and rocuronium. Arterial gases upon admission were FiO20.45, pH7.329, pCO232.9, pO2283, Hb7.5, Ht23.5, HCO3-16.8, BE-7.9, Lac57.

We performed emergency laparotomy and packing surgery while the patient was still partially inflated, and when we confirmed that the bleeding had stopped after 2 hours and 15 minutes, we performed full deflation, which decreased from 116/46 mmHg to 72/36 mmHg, so we performed partial inflate again with 3 ml. The surgery was completed 35 minutes later, and when the patient was given a full deflation again, his blood pressure was stable, so he was deflated and admitted to the ICU with intubation and sedation.

Before the first deflation, 300 ml of extracellular fluid, 4 units of RCC, 6 units of FFP, 420 ml of HES preparation, 200 units of PLT, and 500 ml of 7% melon were administered. Furthermore, 2 units of RCC, 2 units of FFP, 870 ml of

extracellular fluid, and 80 ml of HES were additionally administered before the final deflation.

Postoperative course: FFP and PC were administered in the ICU, the packing was electively removed on the day after surgery, the liver surface was sutured for traumatic liver injury, the patient was extubated on the 2nd day after the emergency surgery, and the patient was extubated on the 4th day after the surgery. The patient was transferred to a general ward. Postoperative ileus was observed after surgery, but the condition improved with fasting, and the patient was discharged from the hospital as his general condition stabilized.

③Patient: 78 years old, female, 157cm, 57kg

Past medical history: Nothing noteworthy

Current history: Injured after crashing into a concrete wall while driving a light vehicle. He was rescued by using a machine to pry open the car door. Upon arrival at the ER, the patient was GCS7 (E3V4M6), blood pressure 169/131 mmHg, SpO2 89% (O212 L/min), peripheral cold sweat was strong, and lung echocardiography showed a negative right sliding sign. Whole body CT showed sternum fracture, anterior mediastinal hematoma, right 8.9th rib fracture, right hemothorax, L3 vertebral body rupture fracture, L3 bilateral transverse process fracture, L1.2 right transverse process fracture, retroperitoneal hematoma, right femur fracture and surrounding hematoma. A 28Fr drainage tube was inserted into the right thoracic cavity, and the bleeding was stopped with a tourniquet at 300 mmHg to the right thigh. Blood transfusion was performed using RBC pumping, but as the state of shock continued, it was determined that intubation was indicated and a 7.5 mm tube was intubated. After intubation, bradycardia and cardiac arrest were observed, so resuscitation was started. The heart and lungs were restarted with heart massage and two doses of adrenaline. Noradrenaline was started at 0.3 μg/kg/min, and REBOA was inserted through the right femoral artery in response to decreased blood pressure. It is unknown how much saline is contained. At the ER, 12 units of RBC, 2 units of FFP, and 10 units of PC were administered, and emergency surgery was performed for the purpose of amputation of the right lower leg.

Surgery: PS4E, vitals upon admission: BP82/62mmHg, HR94bpm, SpO2100%, noradrenaline 0.3μg/kg/min. Ketaral 30mg was administered for

analgesia and sedation, and anesthesia was performed with sevoflurane 0.8%. I don't use drugs because I can't keep my blood pressure up. Aline measurement was impossible during the surgery, probably due to decreased blood pressure and peripheral vasoconstriction, so it was retaken twice under echo guidance. During the surgery, the blood pressure remained at around 60/50 mmHg, and when REBOA was half-deflated, the systolic blood pressure decreased to the 40s, so a vasopressin preparation was continuously administered at 2 U/hour, and finally epinephrine was also given at 0.1 μg/kg/hour. It was started at min. For intraoperative fluid transfusion, 30 units of RBC, 12 units of FFP, 10 units of platelets, 750 ml of 5% albumin preparation, 1000 ml of HES preparation, and 500 ml of extracellular fluid were administered. Electrolyte abnormalities were corrected with calcium gluconate and bicarbonate. During the surgery, a CV double lumen catheter was inserted through the right internal vein. Surgery included amputation of the right lower extremity and external fixation of the left lower extremity. The surgery time was 1 hour and the anesthesia time was about 2 hours, but only 1/4 of the time was able to be partially deflated. Postoperatively, bleeding was observed from the chest drain, and due to unstable blood pressure, contrast-enhanced CT was performed to confirm the source of the bleeding. Compared to preoperative CT, the thoracoabdominal wall and retroperitoneal hematoma were markedly enlarged, the possibility of injury to the inferior thyroid artery and left subclavian artery branch injury due to pneumothorax, free air in the peritoneal cavity, pneumatosis intestinalis, and mesentery. Intravenous emphysema and superior mesenteric artery emphysema were newly observed. As it was difficult to maintain the patient's vitals, the attending physician consulted with the family and decided not to provide any further treatment, and the patient was confirmed dead shortly after being admitted to the ICU.

④Patient: 48 years old, male, 167 cm, 70 kg (visual measurement)

Past medical history: Nothing noteworthy

History of current illness: Injury caused by a solo motorcycle accident in a highway tunnel. When the patient was contacted by the emergency services, he had impaired consciousness, and the previous doctor was unable to measure his blood pressure (the femoral artery was palpable), so he was transferred to our hospital

for treatment. Upon arrival at our hospital's ER, vital signs were GCS 15 (E4V5M6), NIBP unmeasurable, heart rate 121bpm, and SpO2 100% (O210L/min). There were open wounds on the right shoulder, left elbow, and right lower leg, and the right dorsalis pedis artery was not palpable. Her vitals were in shock, and she was intubated at the ER. A REBOA was inserted into her right lower leg, and her blood pressure was maintained at 90/60 mmHg with half inflate. Preoperative whole body CT revealed fractures of the right scapula, right clavicle, right femur, and tibia, with surrounding hematoma and subcutaneous emphysema. The right lower leg was found to have an open fracture of the right femur, an open fracture of the right ankle, an open fracture of the right Lisfranc, and an open fracture of the right tibia, with extensive degloving injuries from the right groin to the distal thigh. Right lower limb amputation was scheduled.

Surgery: PS4E, vitals on admission were BP 83/57, heart rate 121 bpm, SpO 2 100%. Arterial gas analysis upon admission showed pH of 7.4, Hb of 5.9 g/dl, Ht of 5.9%, and lactic acid of 118 mg/dl. Anesthesia was maintained using a small amount of fentanyl, rocuronium, and ketalal, and norepinephrine 0.05-0.3 μg/kg/min. Electrolyte abnormalities were corrected with calticol, calcium chloride, meiron, etc. After using noradrenaline and administering RCC and FFP, the blood pressure rose to 109/72 mmHg, so when REBOA was fully deflated, the blood pressure decreased to 48/32 mmHg, and the patient was inflated again. After starting surgery on the right lower extremity, a large amount of bleeding was observed on the gauze in the right shoulder area, and active bleeding was observed when the right shoulder area was checked. The patient was reported to an orthopedic surgeon and a search for the source of the bleeding revealed that the right subclavian artery had been transected and bleeding was occurring. Cardiovascular surgery was consulted, and a vascular anastomosis using a clamp and the right great saphenous vein was immediately performed. During this time, his blood pressure cannot be maintained, so he remains inflated. Intraoperative systolic blood pressure was 40-70 mmHg, and fluid transfusions included 30 units of RCC, 32 units of FFP, 10 units of PC, and 4500 ml of extracellular fluid.

After returning to the ICU, the patient developed bradycardia and suffered cardiac arrest shortly after.

	1.	2.	3.	4.
age gender	66 year old male	20 year old male	78 year old woman	48 year old male
Mechanism of injury	traffic trauma	traffic trauma	traffic trauma	traffic trauma
Blood transfusion amount	RCC8, FFP14	RCC 6,FFP 8PC10	RCC 30,FFP 12,PC20	RCC 30,FFP 32,PC10
REBOA position	Zone2	not clear	Zone1	not clear
REVOA raw food amount	25ml	3ml	not clear	not clear
REBOA time	57 minutes	2 hours or more	not clear	not clear
catecholamines	N.A.D.	N.A.D.	NAD,AD ,VSP	NAD,AD ,VSP
complications	none	none	intestinal pneumatosis etc.	not clear
prognosis	Good	Good	death	death

Discussion

REBOA may be performed as an emergency evacuation procedure immediately before cardiac arrest, as in this case, or as a preventive placement when hemodynamic failure is expected during planned surgery (radical hemostasis). be. The REBOA is placed in Zone 1 (the branch of the celiac artery from the left subclavian artery) for intraperitoneal bleeding, and in Zone 3 (abdominal aorta beyond the renal artery) for retroperitoneal hemorrhage associated with pelvic fracture. It is not recommended for Zone 2 in between. The length of indwelling in Zone 1 is 41.4 cm to 47.4 cm for 98.7% of people, and in Zone 3 it is 23.6 cm to 25.6 cm for 94.9% of people. Additionally, the recommended amount of saline during balloon expansion is approximately 8 ml in Zone 1 and 3 ml in Zone 3.

Complications of REBOA include vascular injury (e.g., arterial dissection, rupture, perforation) during sheath insertion into the femoral artery, embolism, air embolism, and lower extremity ischemia. 2 In addition, balloon rupture during inflation, organ ischemia due to long-term indwelling, ARDS due to release of interleukin-6, and shock due to ischemic metabolites when the balloon is rapidly deflated can occur.

It is important to use partial blockade or temporary complete blockade as a method to avoid organ ischemia and leg ischemia. According to a report by Norii et al., complete blockage in Zone 1 for more than 45 minutes leads to an increase in mortality rate. [3] Saito et al. also found that the shorter the inflation time, the higher the 24-hour survival rate .

In the two cases that I experienced in which I was able to save a life, I performed partial blockade as described above, and complete deflation while monitoring blood pressure in a timely manner. In two cases with a poor prognosis, partial blockade was performed to avoid organ ischemia, but due to the drop in blood pressure, full inflate was required again, and the inflate time was obviously longer. One patient had complications such as intestinal pneumatosis, which suggested organ ischemia on postoperative CT. Furthermore, bleeding from the chest wall and subclavian artery, which were not noticeable on preoperative CT, may have been exacerbated by the increased perfusion pressure caused by REBOA.

The anesthesiologist plays a major role in the intraoperative management of patients with hemorrhagic shock of American society of anesthesia physical status (ASA-PS) 4E or 5E, such as in this case. They are likely to play the role of commander in guidelines for critical bleeding, and are required to use appropriate transfusion products, discuss surgical procedures with the surgeon, and even contact the transfusion department. In addition, administration of catecholamines is required to correct acidosis and electrolyte abnormalities and to lower blood pressure. Coagulopathy in trauma is due to iatrogenic dilution of coagulation factors due to fluid resuscitation, hypothermia, and acidosis. Furthermore, acute traumatic coagulopathy (ATC) occurs early after injury and is proportional to the severity of the injury. Severe hemorrhagic shock can also result in platelet dysfunction and disseminated intravascular coagulation (DIC). Medical treatment includes coagulation system replacement therapy through blood transfusions and adjunctive therapy such as antifibrinolytic drugs, and in recent years, replacement therapy has

begun to include thromboelastography (TEG) and rotational thromboelastometry (ROTEM). Perform goal-directed transfusion therapy.

There is no doubt that REBOA is a useful device for stopping bleeding, but it can be fatal due to prolonged inflate and complications during insertion. Furthermore, in cases of multiple trauma, there may be unknown sources of bleeding, such as in the upper extremities, head, or thoracic cavity. Even in such a tightrope situation where one wrong step can greatly disrupt a patient's condition, anesthesiologists always consider abnormalities in the surgical field, the patient's entire body, the drain, etc. We need to discuss the inflate time of REBOA and the time required to stop the bleeding, and decide whether to go for partial deflation or full deflation, and to achieve a stable state while controlling blood pressure.

Conclusion

Although REBOA is an effective treatment for massive bleeding, it is necessary to consider the elapsed time and complications before using it.

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