

Figure 1 Contrast-enhanced computed tomography of the abdomen two hours after the injury, showed abdominal bleeding, contrast leakage in the pancreatic head (arrow), and retroperitoneal hematoma (circle).

complains of abdominal and back pain. He got drunk with alcohol and quarreled with his neighbor and had been assaulted with a fire extinguisher in his abdomen 1 hour prior to presentation. He seemed restless, and physical examination revealed tenderness of the upper abdomen with the following vital signs: blood pressure, 67/40 mmHg; heart rate, 124 beats/min; respiratory rate, 20 breaths/min; oxygen saturation, 100% (O_2 10 L/min); and Glasgow coma scale, E3V4M5. Further, the hemoglobin concentration was 14.3 g/dl, amylase concentration was 104 U/l, lipase concentration was 178 U/l, lactate concentration was 28 mg/dl at the presentation. Focused assessment with ultrasonography for trauma detected hemoperitoneum.

Fluid resuscitation was performed, and his blood pressure improved. Because he was restless and we could not perform further evaluation, the patient was intubated with sedation. Contrast-enhanced computed tomography (CT) showed abdominal bleeding and retroperitoneal hematoma due to pancreatic head injury with contrast leakage (Fig. 1). We decided to perform an emergency laparotomy to explore his abdomen and secure hemostasis.

The abdomen was explored through a long midline incision. There was a large hematoma in the upper retroperitoneum upon removal of the clots in the abdominal cavity. To identify the source of the bleeding,

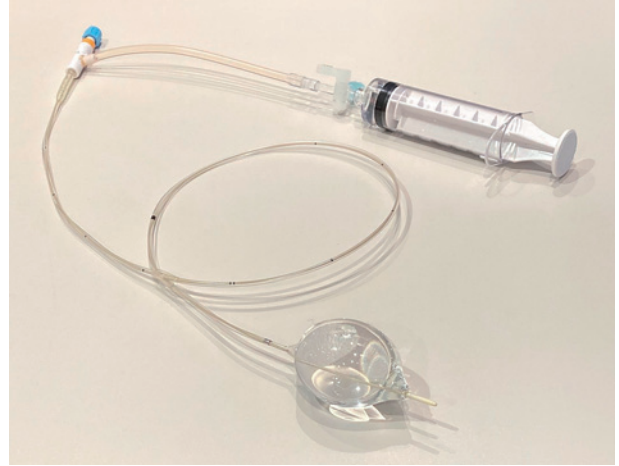


Figure 2 A photograph of REBOA (RESCUE BALLOON®, Tokai Medical Products, Aichi, Japan). RESCUE BALLOON® is compatible with 7 Fr introducer sheath.

we attempted to explore the retroperitoneal hematoma. However, eruptive bleeding from the retroperitoneal hematoma occurred, necessitating gauze packing. His blood pressure dropped, and it became difficult to identify the source of bleeding.

We decided to insert a REBOA (Tokai Medical Products, Aichi, Japan) (Fig. 2) from the femoral artery for temporary hemostasis. The REBOA was inserted in zone 1 using an external anatomical landmark (the suprasternal notch and xiphoid process). The REBOA was successfully inserted, and the balloon was inflated to the minimum amount of saline that would increase his blood pressure; thus, his blood pressure returned to normal. Moreover, we easily detected the injured inferior pancreaticoduodenal vessels (bleeding source) and ligated it, resulting in definitive hemostasis (Fig. 3). The oozing in the injured pancreatic head was sheathed with compression and the TachoSil tissue sealing sheet (CSL Behring, Pennsylvania, USA). However, oozing around the pancreatic head was confirmed after deflation of the balloon, although the eruptive bleeding was controlled. The total aortic occlusion time was 43 min. The oozing was managed with compression by gauze packing, and hollow viscus injury was not confirmed. The amount of blood lost during surgery was 3400 mL. His body temperature decreased; therefore, we decided to perform a damage control strategy. His abdomen was temporarily closed, and he was admitted to the intensive care unit for re-

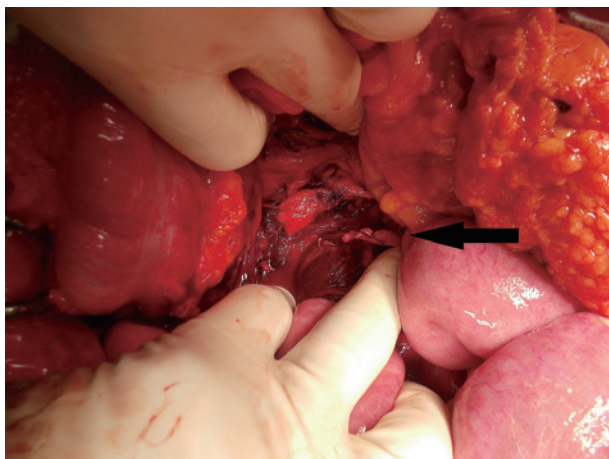


Figure 3 An intraoperative photograph of the injured pancreas head at the first surgery. After inflation of REBOA, injured vessels could be easily detected. Anterior branch of the inferior pancreaticoduodenal artery and vein were injured and ligated (arrow). Posterior branch of the inferior pancreaticoduodenal artery and vein were also injured and ligated (not shown in this photograph).

warming and adequate blood transfusion.

The second-look operation was performed one day after the injury. The oozing had stopped, and no other organ injury was found. The abdominal wall was closed, and he was extubated two days after the injury. He experienced neither a pancreatic fistula nor a pancreatic duct injury, although he experienced stenosis in the third portion of the duodenum ten days after injury, requiring total parenteral nutrition. However, the stenosis of the duodenum improved conservatively, and he was discharged 63 days after the injury.

Discussion

The use of REBOA for bleeding control was reported in 1953 by Edwards et al., who pointed out the possibility of controlling massive abdominal bleeding⁵. It is also reportedly effective in trauma patients with truncal or junctional bleeding⁶. More so, REBOA can reduce non-compressible bleeding and increase blood flow to the brain and heart temporarily. For this mechanism, the use of REBOA was expected to improve mortality in patients with truncal or junctional trauma. However, recent reviews have shown no evidence of improved survival despite its efficacy in increasing blood pressure^{1,7}.

The best indication for REBOA remains unclear in trauma patients^{1,2}, and studies are needed to specify the subcategory of patients that will benefit the most from balloon deployment^{2,8}. Indications for REBOA in trauma patients were described as life-threatening hemorrhage below the diaphragm in patients with hemorrhagic shock who are unresponsive or transiently responsive to resuscitation¹. However, this indication includes patients who do not benefit much. Other factors need to be taken into consideration to determine the best indications for REBOA.

Inoue et al. reported that patients with torso trauma who were treated with REBOA had higher mortality than those treated without REBOA⁸. They reported that this difference may be due to a delay in definitive hemostatic treatment. We must be aware that REBOA is not always indicated for hemodynamically unstable patients due to truncal or junctional trauma, and definitive hemostasis must be performed in a hurry.

Detection of a bleeding source is necessary for definitive hemostasis. When massive bleeding occurs in the abdominal cavity, gauze packing may be needed to stop the bleeding temporarily and to detect the source of bleeding. It is not easy to identify and repair the injury site simultaneously while compressing the source of bleeding. Even if the bleeding source is detected, to achieve definitive hemostasis may be difficult due to continuous bleeding and/or compression.

Further, REBOA enables bleeding control from outside the operation field and is extremely effective for maintaining a good bloodless field of operation³. If REBOA is properly deployed, it helps to detect the source of bleeding and to perform definitive hemostasis⁴ in the early stage of operation with a smaller amount of bleeding. It is thought that the true value of REBOA will be demonstrated in such a case. Hence, if the source of bleeding cannot be detected due to truncal or junctional injury below the diaphragm due to catastrophic bleeding, and/or if definitive hemostasis cannot be performed due to continuous bleeding from the detected sources, REBOA may be a good indication.

In conclusion, the best indication for REBOA remains unclear in patients with trauma. However, the use of REBOA to maintain a bloodless operative field to detect the source of bleeding in hemodynamically unstable patients who suffer truncal or junctional

trauma, and/or the use of REBOA for definitive hemostasis, which is difficult to manage due to continuous bleeding, may be a good indication.

Patient Consent

Written informed consent was obtained from the patient for publication of this report and the associated images.

Author Contributions

MS: Developing the concept of this case report and writing the manuscript.

RN: Editing this manuscript.

SG: Editing this manuscript.

DS: Developing the concept of this case report and editing this manuscript.

HM: Final editing this manuscript.

All authors approved the submission of the final article.

Disclosure Statement

The authors declare no conflict of interest. No funding was received.

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