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Case Report

Transsplenic Ultrasound-Guided Balloon Positioning During a Zone 1 Resuscitative Endovascular Balloon Occlusion of the Aorta: A Case Report

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ABSTRACT

Resuscitative endovascular balloon occlusion of the aorta (REBOA) is an effective resuscitative modality to temporize noncompressible truncal hemorrhage. Confirming the proper position of the balloon catheter in the target aortic zone is vital. Currently, there is a need for nonradiographical methods. This would overcome the drawbacks of conventional imaging modalities, such as fluoroscopy. Several studies have suggested ultrasound-guided visualization via subxiphoid, transperitoneal, or transesophageal views as an alternative to conventional imaging methods. However, such views are easily obscured in emergency settings. Herein, we report the case of a 70-year-old patient who was successfully resuscitated by REBOA under the guidance of transsplenic ultrasound. REBOA was safely performed using transsplenic visualization without fluoroscopy.

Keywords: aorta, balloon occlusion, resuscitation, spleen, ultrasonography

Introduction

Resuscitative endovascular balloon occlusion of the aorta (REBOA) is an emerging adjunct therapy used to occlude the aorta at a site proximal to the hemorrhage until definite repair of the injury can be achieved [1]. REBOA usage has peaked due to improvements in balloon technology and favorable outcomes [2]. However, a significant drawback of REBOA is the dependence on fluoroscopy or X-ray for the correct anatomical positioning of the catheter. Unintended inflation in the aortic arch and renal or contralateral iliac artery can lead to severe complications [3]. Identifying faster and effective alternatives for REBOA is a challenge faced by trauma surgeons. In addition, this procedure should be portable, which is essential for its broader application in the prehospital settings [4,5].

Ultrasound (US) is a ubiquitous tool that offers mobility and expeditiousness in the emergency setting. The use of US as a novel imaging modality during REBOA has been previously described in the studies where subxiphoid, transperitoneal, or transesophageal views were used to confirm the correct intraaortic positioning of the catheter [4,6-9]. However, a transsplenic approach has not been reported, even though inspection of the splenorenal space is a part of the focused assessment with sonography for trauma (FAST) protocol.

Case Report

A 70-year-old male patient presented in a state of semicoma after a motorcycle crash. Upon arrival, the patient was hemodynamically unstable with a blood pressure of 71/54 mmHg and a pulse rate of 120 beats/minute. A FAST examination showed fluid collection in the splenorenal recess and absence of lung sliding on the left side. Endotracheal intubation and a closed thoracostomy were performed. The hemoglobin level was 6.5 g/dL. Computed tomography revealed severe brain hemorrhage and multiple torso injuries, including a Grade 3 splenic laceration. As the patient's blood pressure deteriorated, REBOA in the supra-diaphragmatic location (Zone 1) was performed according to the algorithm for REBOA usage in hemorrhagic shock at Dankook University hospital (Figure 1), and the blood pressure increased to 140/82 mmHg. He underwent an emergency craniectomy, but died due to irreversible brain damage following surgery (Figure 2).

Technique used in the transsplenic method

A 7-Fr introducer sheath and a 0.025-inch guidewire were inserted in the left common femoral artery using the Seldinger technique. After measuring the distance from the sheath to the xiphoid process, a 7-Fr balloon catheter (Rescue Balloon, Tokai Medical Products, Aichi, Japan) was blindly advanced up to 50 cm along the wire and the balloon was partially inflated with 5 mL of saline. With the patient in the supine position, a curved array probe with a median frequency of 2-4 MHz was positioned at the 10th intercostal space for a posterolateral approach (Figure 3). A longitudinal view of the spleen in the coronal plane was observed. By angling the transducer anteriorly and posteriorly, the infradiaphragmatic aorta was visualized. Further, the balloon

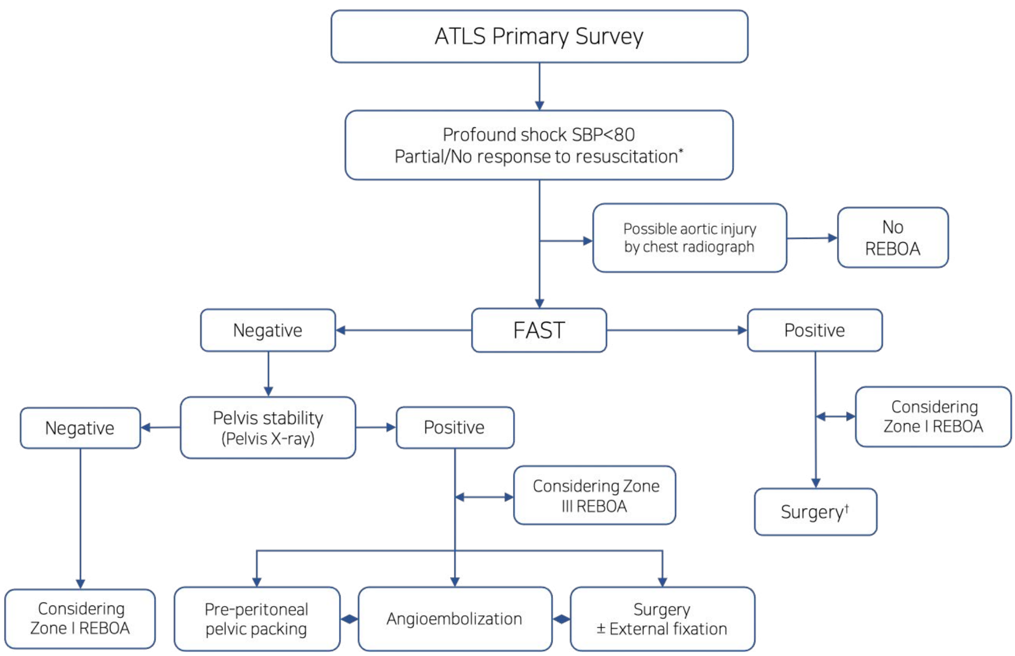

Figure 1. Algorithm developed by Dankook University Hospital, Level 1 trauma center for REBOA usage in hemorrhagic shock [1].
* Early transfusion in resuscitation room and no possible aortic injury by chest radiography.
† Door-to incision time less than 30 minutes. REBOA, resuscitative endovascular balloon occlusion of the aorta.
ATLS = advanced trauma life support; FAST = focused assessment with sonography for trauma; SBP = systolic blood pressure.

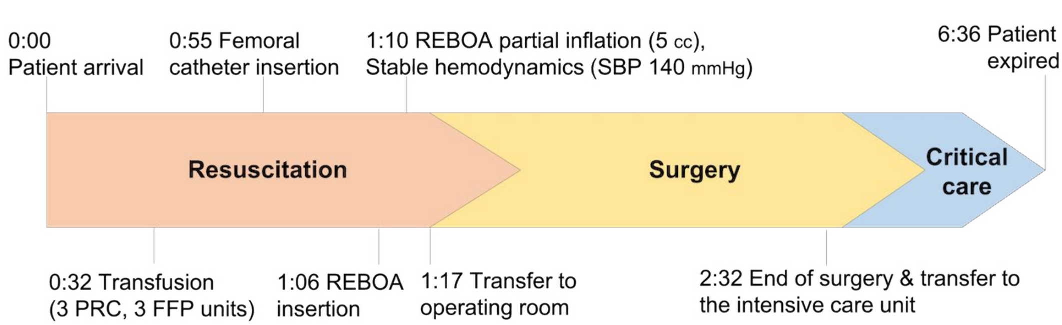

Figure 2. Time course through resuscitation, surgery, and critical care (hours and minutes).
FFP = fresh frozen plasma; PRC, packed red blood cell; REBOA, resuscitative endovascular balloon occlusion of the aorta; SBP, systolic blood pressure.

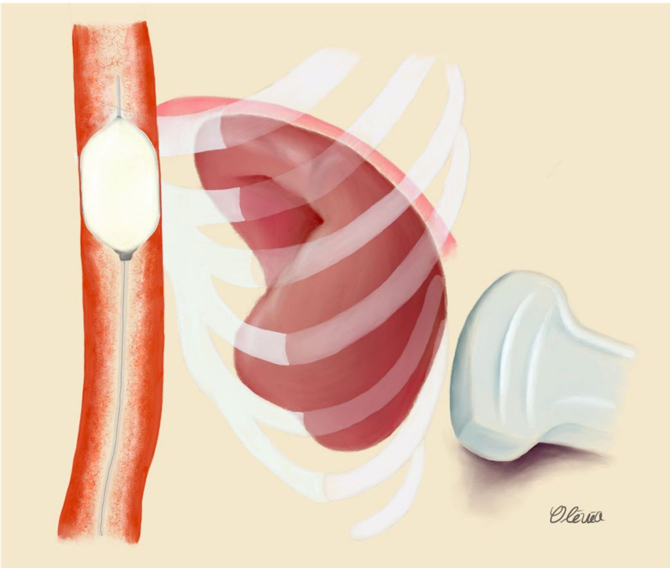

Figure 3. The transsplenic method during resuscitative endovascular balloon occlusion of the aorta in Zone 1.

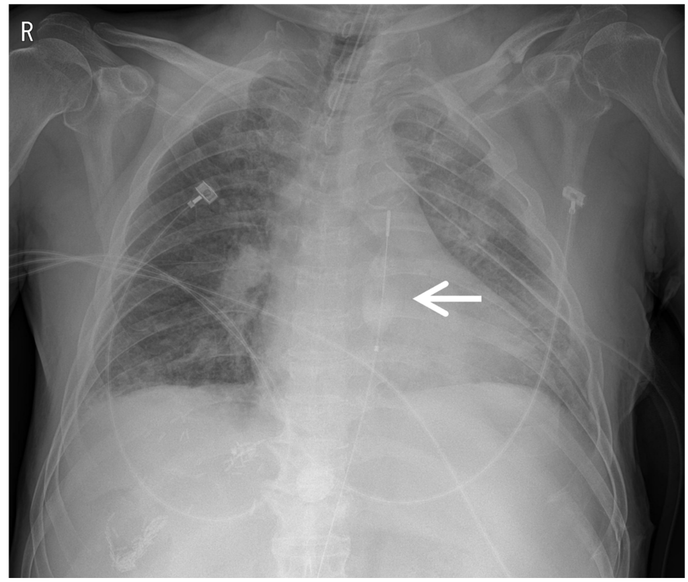

Figure 5. Position of the 7-Fr balloon catheter (arrow) in the aortic Zone 1 was reconfirmed by X-ray.

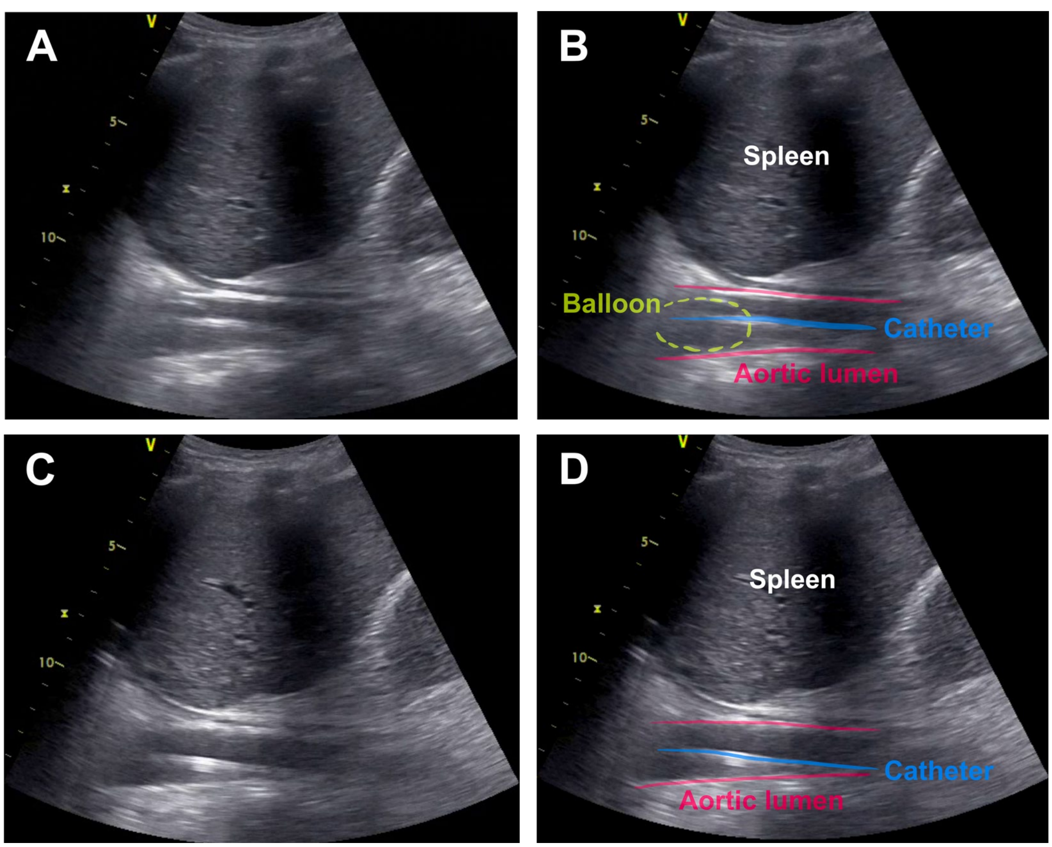

Figure 4. A transverse view of the abdominal aorta using the transsplenic method. (A and B) initially, the inflated balloon was located underneath the diaphragm. (C and D) after advancing the catheter by 5 cm cephalad, the balloon was no longer observed.

and shaft of the catheter were observed by maintaining this view along the long axis of the aorta. As the balloon was located underneath the aortic hiatus (Figures 4A and B), the catheter was advanced to 5 cm in the cephalad direction to achieve Zone 1 REBOA (Figures 4C and D). The position was reconfirmed by an X-ray and the measured distance between the inferior end of the balloon and the diaphragm was 5 cm (Figure 5).

Discussion

The aorta is divided into 3 zones while performing REBOA: Zone 1 is supradiaphragmatic and distal to the left subclavian artery but proximal to the celiac artery; Zone 2 is between the celiac trunk and the renal arteries; and Zone 3 is below the renal artery but proximal to the iliac bifurcation [1]. Cardiac tamponade or thoracic aortic injury is a known contraindication of REBOA; however, concomitant traumatic neurological injury is not [1,10]. Mispositioned REBOA outside aortic Zones 1 and 3 can lead to severe complications in a patient already in extremis. Further, REBOA in the aortic arch creates excessive afterload and myocardial injuries, leading to blockage of cerebral blood flow. Zone 2 REBOA can potentially result in ischemia of visceral organs and exacerbation of bleeding in the celiac axis [3]. Thus, confirmation of the accurate position of the balloon catheter is critical during REBOA.

Fluoroscopy has been considered the gold standard for imaging-guided REBOA [11]. Meanwhile, current studies have demonstrated that the prehospital use of REBOA increased survival rate [2]. If REBOA is to be used in field settings, it is essential to develop a method that requires least equipment and personnel. Therefore, various modalities have been proposed, such as radiofrequency identification [11], magnetic tracking [3], and US [4,6-9]. US guidance is potentially the most suitable candidate due to its increasing bedside use during FAST. However, subxiphoid, transperitoneal, and transesophageal approaches for US guidance have been described with several limitations. Most of those studies were conducted on perfused cadavers or fasting patients [4,6-8] and used a contrast agent that is usually not available in the emergency department [4]. Thus, we used the transsplenic US, which is less obscured under emergent conditions.

The 9-11th intercostal spaces in the left side represent the optimal window for transsplenic imaging. Homogeneous echogenicity and location of the spleen render transsplenic US useful during REBOA. The exact location of the catheter can be determined by correcting the sonographic angle such that the entire length of the aortic lumen runs parallel to the coronal plane. This will ensure that the US beam intersects the spleen perpendicular to the aorta (Figure 6). Further, the bowel is unlikely to be situated between the spleen and probe, which prevents interference of acoustic transmission. Nonetheless, care must be paid to the possible presence of the gastric fundus between the spleen and the aorta.

To the best of our knowledge, this is the 1st report that demonstrates the applicability of transsplenic US for safe and accurate Zone 1 REBOA. However, this method has some limitations. The sonographic window is compromised by obesity, pneumoperitoneum, subcutaneous emphysema, and tortuous or calcified aorta [7]. The method cannot be used in patients with splenic injury, external wounds on the left side, or after a splenectomy. The broad sensitivity due to variations in operator skill is a shortcoming of using US. Future studies are

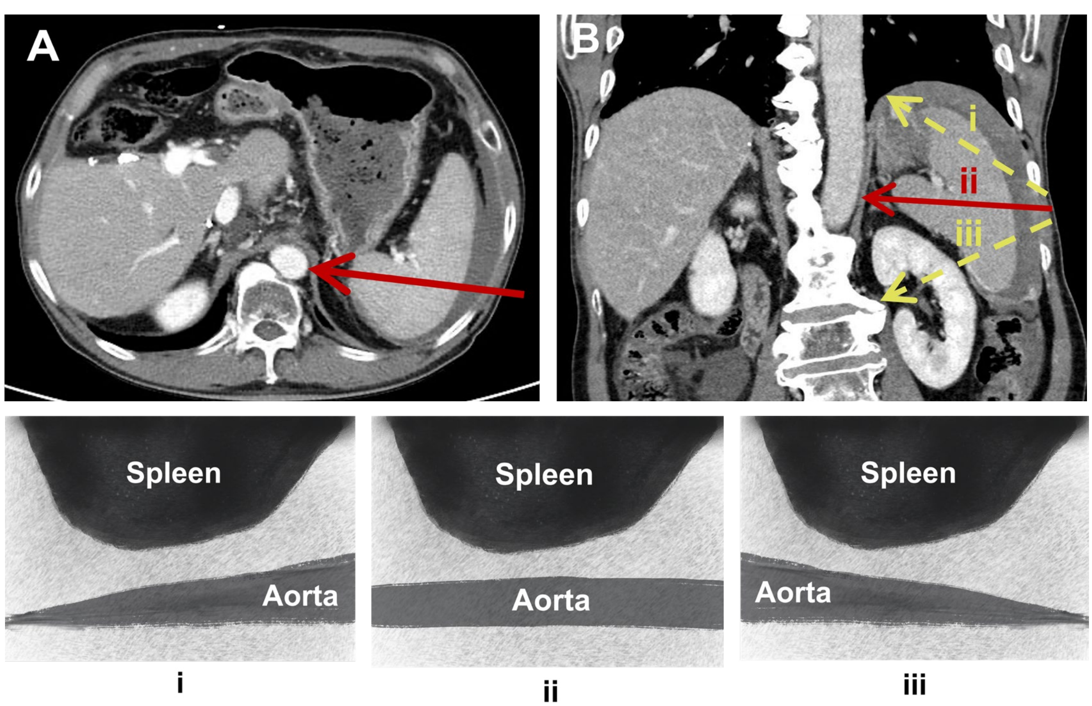

Figure 6. The optimal sonographic window (A) in the sagittal, and (B) coronal computed tomographic images (solid arrows). Perpendicular images are desirable (ii) as inappropriate angles lead to wrong locations for the catheter (i, iii).

needed to assess the success rate of this method to achieve an acceptable level of sensitivity.

In summary, there is a need for faster, effective portable imaging modalities to replace the current standard methods used during REBOA. This case demonstrates that REBOA can be safely performed using transsplenic visualization without fluoroscopy. Therefore, we recommend transsplenic US-guidance as an option when visualization using other approaches is not possible during REBOA.

Author Contributions

Methodology, conceptualization and writing - review & editing: SWC, DHK. Investigation, visualization and writing - original draft: YH. Project administration: DHK.

Conflicts of Interest

The authors have no conflicts of interest to declare.

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None.

Ethical Statement

This research did not involve any human or animal experiments.

Data Availability

All relevant data are included in this manuscript.

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