Case Report

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Be Aware: REBOA May Increase Liver Bleeding

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INTRODUCTION

Severe liver injuries are rarely encountered, however, they are associated with a high mortality rate [1]. Regardless of grade severity, most liver injuries are treated non-operatively. The single indication for surgery, in the absence of other injuries requiring explorative laparotomy, is hemodynamic instability [2]. Surgery in these patients is complicated due to a rapid development of traumatic coagulopathy, followed by hypothermia and acidosis. The opening of the abdominal cavity is often associated with deterioration of hemodynamic status, with a decrease in blood pressure and even hemodynamic collapse. The mechanism is multifactorial but mostly results from the use of anesthetic drugs that have vasodilatory effects [3]. The decrease in systemic blood pressure in massive bleeding might, at times, force the trauma surgeon to perform procedures such as thoracotomy and aortic clumping, which would not have been considered in more favorable situations. With the introduction of resuscitative endovascular balloon occlusion of the aorta (REBOA) and the immediate availability of this technique in some hospitals, in selective cases, REBOA is performed simultaneously with explorative laparotomy as part of the EndoVascular Trauma and Bleeding Management (EVTM) concept [4,5]. In this way, it is possible to obtain a reasonable blood pressure and to "buy" time for more planning and less extensive procedures. We hereby report a case of a patient with a severe blunt liver injury who required a non-anatomical right hepatectomy, where inflation of the intra-aortic balloon would certainly worsen bleeding. The clinical course and therapeutic dilemmas are discussed.

Case Description

A 19-year-old previously healthy male was brought to our trauma unit after a bicycle accident. At the scene, he was stable and had a Glasgow Coma Score of 15. On admission, his blood pressure was 120/78 mmHg, heart rate was 90 beats per min, and he had a pulse oximetry of 95%. Respiration, as well as heart sounds, were normal. On physical examination, multiple abrasions on the anterior chest and abdominal wall were noted. The abdomen was distended and tense. The remainder of the physical examination was unremarkable. Focused assessment with sonography for trauma (FAST) did not reveal any sign of pericardial fluid but did present with a large amount of abdominal fluid. Portable chest x-ray was interpreted as normal. Head, spine, and chest computed tomography (CT) were without findings. Abdominal CT angiography demonstrated right lobe liver laceration grade 5, reaching the hepatic hilum with no signs of arterial or venous extravasation (Figure 1). In addition, a grade 3 spleen laceration was noted, as well as a significant amount of intraperitoneal fluid. Due to his stability, a decision for non-operative management was made, and the patient was admitted to the ICU. Within the next two hours, laboratory results showed a

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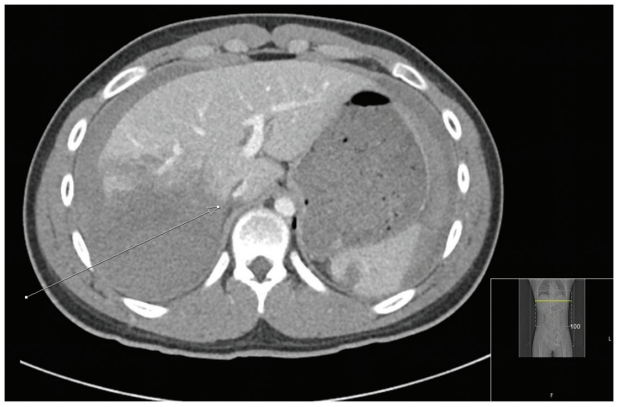

Figure 1 Demonstrating grade V liver laceration. The white arrow shows the tear reaching the liver hilum.

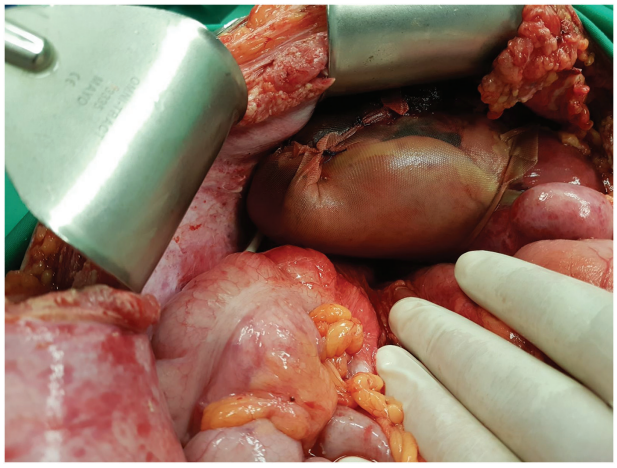

Figure 2 This figure shows the remaining liver after non-anatomical right keratectomy, wrapped with absorbable Vicryl mesh 30 × 30 cm.

drop in his hemoglobin from 11.9 g% to 8.3 g%. Immediate blood transfusion of two units of PC was initiated, and the plan was to refer the patient to hepatic angioembolization. Suddenly, a few hours later, his blood pressure dropped to 80 mmHg, and the patient did not respond to massive blood and fluid resuscitation. The patient was immediately brought to the operating room and the REBOA protocol was activated. Simultaneously, with the initiation of explorative laparotomy, right groin femoral access was achieved by an interventional radiologist using a femoral sheath 8 Fr 10 cm Radifocus Introducer II (Terumo Medical Corp. Ethicon, MD, USA) and an intra-aortic balloon (Rescue Balloon, Tokai, Japan) was inserted and placed according to a catheter 40 cm external marker. In surgery, more than 2.5 liters of blood were evacuated from the abdominal cavity and the abdomen was initially packed. Exploration of the abdomen revealed a large right lobe liver laceration and a grade 3 spleen laceration. Splenectomy was performed as well as peri-hepatic packing. At this point, the patient's blood pressure dropped to 48 mmHg and the balloon was inflated approximately 7 minutes afterward. Immediately after this procedure the blood pressure rose to 155/84 mmHg but bleeding from the liver worsened. This required suture of the liver using local hemostat and additional liver repacking. Total balloon occlusion time was about 15 minutes and then the balloon was deflated. After completion of the procedure, the surgeon's perception was that the peri-hepatic packing itself might be insufficient and that the patient needed additional surgery with on-table angiography and hepatic embolization. During the angiography, several attempts to catheterize the celiac trunk failed and the patient's blood pressure decreased again, to 50 mmHg. A relaparotomy and immediate Pringle maneuver was performed. This procedure did not improve the situation and under these circumstances, it was decided to perform a non-anatomical right hepatectomy, followed by liver wrapping, using absorbable Vicryl mesh (Figure 2). Due to critical hemodynamic instability, the aortic balloon was fully inflated several times to achieve a reasonable blood pressure. Each time a systolic blood pressure of 90 mmHg was reached, a partial balloon deflation (pREBOA) was done. When blood pressure dropped below the targeted level, the balloon was once again fully inflated. However, each attempt at balloon inflation led to worsening of the liver hemorrhage. After completion of hepatectomy and liver wrapping, the blood pressure became progressively stable; therefore, the balloon was deflated. The total intermittent REBOA (iREBOA) time was one hour. The remaining liver was repacked again, and the abdomen was left open using a Bogota bag. During the procedure, the patient received 22 units of packed red blood cells, 8 units of FFP, and other replacement products. The patient's condition improved gradually and the femoral artery sheath was removed the following day. After 48 hours the abdominal packs were removed, however, the abdomen was left open. On post-operative day 7, the patient underwent definitive abdominal closure using absorbable Vicryl mesh. On post-operative day 10, the patient was successfully extubated and started oral feeding.

DISCUSSION

Surgical treatment of severe liver injuries remains very challenging despite advances in surgical techniques, development of local hemostats, and different devices for hemostasis, such as the cavitational ultrasonic surgical aspirator (CUSA) and the argon coagulator. One of the major problems is that the hemostasis must be achieved quickly. Bleeding from the liver lowers the amount of coagulation factors and causes rapid development of traumatic coagulopathy.

The most acceptable and rapid maneuver for liver hemostasis is peri-hepatic packing [5]. However, in some cases, the packing may be ineffective and there is

an urgent need to perform more sophisticated procedures in patients who are unable to tolerate extensive surgery [6]. REBOA enables a rapid increase in systemic blood pressure. The indications for REBOA usage are still not well defined, however, a recent EVTM Society consensus has clearly indicated the use of this technique in hypotensive trauma patients suffering from massive bleeding [7]. Limited data suggest that the use of pREBOA (or iREBOA) might be beneficial with a higher survival rate [8]. It has been shown that in cases where there is a sudden deterioration of the trauma victim, a resuscitation strategy by the inflation of a previously inserted REBOA, may achieve an increase in systemic blood pressure and can prevent the extension of surgery for thoracotomy with above/below the diaphragm aortic clumping [9]. In our opinion, it is very important to achieve arterial access at an early stage of trauma management, in order to prepare for the worst scenario. Confirmation of the balloon placement may be done in several ways, such as fluoroscopy, ultrasound or even CT scan. In most emergency situations, the balloon is inserted blindly using external catheter markers. The accurate distance for reaching different zones of occlusion is not clear. In a cadaver study, Linnebur et al. [10] found that the average distance from the common femoral artery puncture sites to the mid-sternum and xiphoid was a measured mean (SD) of 41.8 (3.3) and 31.8 (3.9) cm, respectively. However, results of this study are limited and cannot be extrapolated to clinical practice, because cadavers are typically representative of older patients and may also exhibit precise morphological differences from living humans [10]. Another study performed on 25 living trauma patients, based on multiplanar CT angiography, showed that the distance from the femoral artery to the celiac trunk ranged from 30–35.2 cm [11]. The proper placement of the balloon is crucial in order to prevent zone II aortic occlusion, since this may expose the patient to the risks of visceral ischemia, without providing significant benefits compared with a zone III occlusion [12]. Based on the literature, a distance of 40 cm should be appropriate for achieving the correct anatomic location. However, without radiologic confirmation, this is not a simple procedure in urgent settings, when height, habitus, and BMI may be inaccurately assessed.

In our case, the decision to perform explorative laparotomy was made when a hemodynamically stable patient, selected for non-operative management, suddenly deteriorated with a dramatic drop in blood pressure and lack of response to blood resuscitation. In this situation, the inflation of the balloon significantly improved the patient's condition. However, after the inflation, we noted a distinct increase in arterial bleeding from the liver. A similar observation was noticed several times when we needed to re-inflate the balloon due to a significant decrease in blood pressure during the hepatectomy and wrapping. Theoretically, closure of the aorta should decrease any arterial bleeding below the occlusion level. This did not happen in our case. We have several explanations for this fact. The balloon was inserted according to a 40 cm catheter marker in a patient with a height of 165 cm. Therefore, it may have been located between the renal arteries and the celiac trunk. Being open from the celiac part and closed below it, this may certainly worsen the bleeding from the hepatic artery and the whole liver surface. Moreover, exacerbation of the hemorrhage may be associated with increased return pressure via the portal vein. However, after the surgery, we performed a reconstruction of the patient's CT imaging and found that the balloon was located in zone 1. In this case, the worsening of bleeding may be explained by a potential increase in collateral perfusion to the liver. Another theoretical option is misplacing of the balloon into the venous system. In such a situation, occlusion of the inferior vena cava will only decrease the systemic blood pressure. We assume that our case observation is important for trauma teams. In such a situation, when the liver hemorrhage worsens despite balloon inflation, immediate replacement of the balloon at a distance further than the accepted 40 cm marker to ensure zone 1 aortic occlusion should be considered. Even then, the balloon inflation may worsen the bleeding resulting from an increased blood flow via collateral perfusion to the liver. Unfortunately, at the time of surgery, we did not clearly understand and did not consider that the worsening of bleeding may be directly associated with REBOA inflation.

CONCLUSIONS

REBOA may worsen liver bleeding in selected cases. This may be explained by improper zone II balloon placement requiring rapid repositioning of the balloon, positioning of the balloon into the inferior vena cava system or an increase of collateral perfusion to the liver. We believe that future research should be performed to confirm our clinical observations.

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