Case Report

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Successfully Stifling Retroperitoneal and Pelvic Exsanguination by Resuscitative Endovascular Balloon Occlusion of the Aorta in a Rural Setting

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Background: Torso hemorrhages are increasingly controlled by transient employment of Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA). Few studies report patients' conditions after the initial resuscitation period using REBOA, especially in a rural setting. We present a highly successful 1-year post-operative recovery using REBOA for retroperitoneal and pelvic exsanguination.
Methods: A 36-year-old female suffered a constellation of traumatic injuries after being ejected from her motorcycle. She arrived at a rural level 1 trauma center shortly thereafter.
Results: REBOA was employed to control profuse hemorrhaging and the patient had a highly resilient recovery after one year. A literature review was conducted to highlight the points of contention regarding the controversial use of REBOA.
Conclusion: REBOA can produce favorable results with minimal long-term deficits when controlling pelvic exsanguination.

Keywords: *REBOA; Pelvic Trauma; Hemostasis; Torso Hemorrhage*

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INTRODUCTION

Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) may be used to stabilize life-threatening pelvic hemorrhages when tourniquets are unfeasible. Among other benefits, it reduces exsanguination and restores blood pressure in profoundly hypotensive patients [1]. There are several reports of REBOA use for pelvic trauma [2,3] but few studies report outcomes after the initial resuscitation period [4]. The use of REBOA is controversial, however. Patients who qualify for REBOA must be selected judiciously as its negative effects may outweigh the benefit of hemostasis [5,6]. We present a case of a highly successful pelvic trauma recovery following a zone 3 (Figure 1) REBOA insertion.

Ethical Approval and Informed Consent

Ethical approval was not required and the information has been anonymised.

CASE PRESENTATION

A 36-year-old female arrived at a rural level 1 trauma center after colliding with a car and being ejected from her motorcycle. She remained awake and alert on the scene despite losing her helmet. She sustained a constellation of fractures involving the pelvic ring, bilateral pubic rami, the C7 vertebra, the right proximal humerus,

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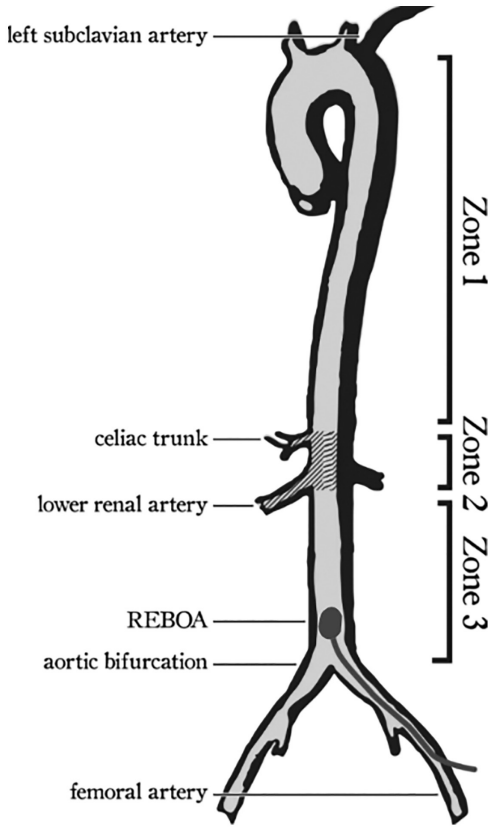

Figure 1 Anatomical distribution of REBOA.
The 3 zones of REBOA placement. Zone 3 consists of the infrarenal aorta. Adapted from Olsen et al. [7] (CC BY 4.0).

and the left femoral shaft (Figure 2) as well as a vaginal laceration. A Glasgow Coma Score of 3T inhibited history taking by emergency medical services personnel. En route she had a heart rate of 140 beats per minute and she was intubated with an endotracheal tube 5.2 cm above the carina. Cefazolin and tranexamic acid were also administered to prevent gram-positive infections and to induce fibrinolysis, respectively.

Upon arrival at the trauma bay a primary survey was conducted. The airway was confirmed, and profuse retroperitoneal and pelvic hemorrhaging were noted to cause hypovolemia with diminished carotid and femoral pulses. She was given two units of packed red blood cells, one liter of crystalloid fluid, and one unit of fresh frozen plasma to correct for hemorrhagic shock. She was also hypokalemic with 3.2 mmol/L of potassium from extensive rhabdomyolysis and hypovolemia. One ampule of bicarbonate was administered via intraosseous access for immediate intracellular potassium restoration. Acidosis was identified with an arterial partial pressure of carbon dioxide of 62.0 mmHg, bicarbonate of 10.6 mmol/L, and a lactate level of 13.7 mmol/L, which contributed to an anion gap of 24 mmol/L. A negative focused assessment with sonography in trauma (FAST) of the abdomen in conjunction with pelvic fractures on X-ray prompted a zone 3 REBOA inflation per hospital protocol. A pelvic binder was applied and a 7 French catheter was inserted through the femoral artery to place REBOA superior to the aortic bifurcation using the Seldinger technique. REBOA was measured at the

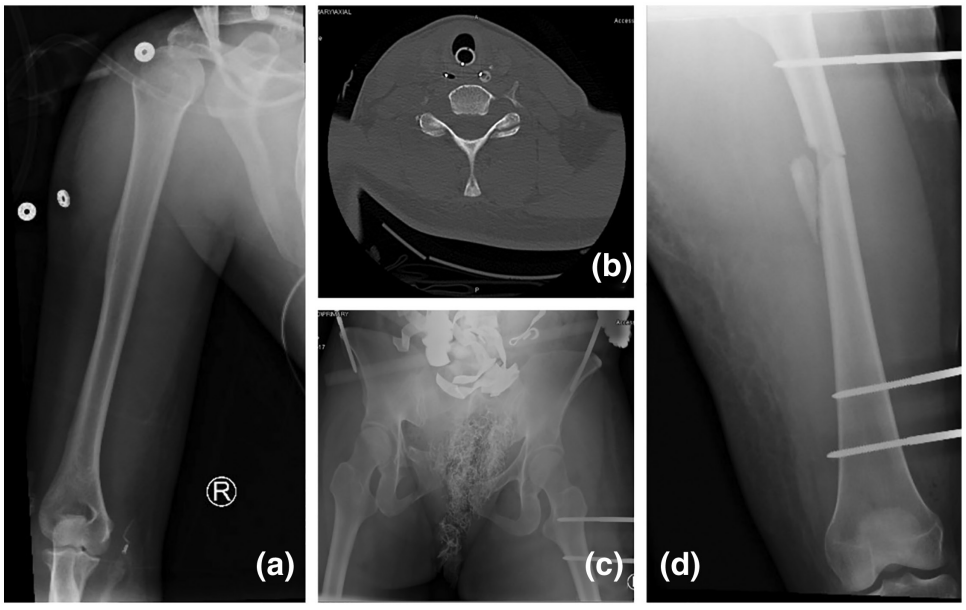

Figure 2 Bone fracture radiographs.
(**a**) Greater tubercle fracture of the right humerus. (**b**) Fracture of the right C7 transverse process. (**c**) Fracture of the right inferior rami. (**d**) Fracture of the left femoral shaft.

Figure 3 Angiogram.
Angiogram imaging of the right external iliac artery. An endovascular stent can be seen dilating the artery.

level of the umbilicus and inflated with 20 cc of saline. Animal studies suggest zone 3 REBOA placement is survivable up to 90 min [8]. Shortly afterward, her blood pressure increased from 94/55 to 148/88 and an echocardiogram verified improvements in cardiac functioning. A triple lumen catheter was secured in the right subclavian artery once initial attempts to insert it on the left were unsuccessful.

The patient was subsequently taken to the operating room for an exploratory laparotomy where a midline longitudinal laceration was identified extending from the vulva to the rectal wall and a thoracostomy was inserted to relieve a left pneumothorax. Hyperresonance on auscultation prompted a chest X-ray which identified the pneumothorax. Prolonged inflation of REBOA risks ischemia downstream of the aortic bifurcation so REBOA was deflated and withdrawn once the internal iliac arteries were bilaterally ligated. Ligation was reversed after two days. A post-operative computed tomography (CT) scan revealed an external iliac artery pseudoaneurysm requiring the insertion of an endovascular stent (Figure 3). The patient returned a month after the Viabahn stent was placed for follow up. At that time, she reported no defects in the right lower extremity but complained of tightness and aching in her left calf which was too debilitating to bear weight on. A venous duplex the same day revealed no deep vein thrombosis (DVT).

After the exploratory laparotomy, her left pelvis and femur were stabilized by an external fixation device. Open reduction and internal fixation of the pubic symphysis, insertion of a left sacroiliac screw, and repair of a comminuted greater tuberosity fracture were later performed. She also underwent a vulvovaginal laceration repair, perineorrhaphy, and an anal sphincteroplasty without complication followed by extensive pelvic floor physical therapy.

Comprehensive physical exams and imaging sought to detect inconspicuous injuries. A CT angiogram revealed a bilateral blunt cerebrovascular injury of the cervical internal carotid arteries (ICAs). Both the right and left ICAs had a dissection or an intramural hematoma, but a pseudoaneurysm was also suspected in the left ICA. Hospital interventional neuroradiologists concluded that intervention was unwarranted and that a 3-month angiogram follow-up alone would suffice. She was discharged from the hospital 27 days after the motorcycle crash and required no further management for her cerebrovascular injuries.

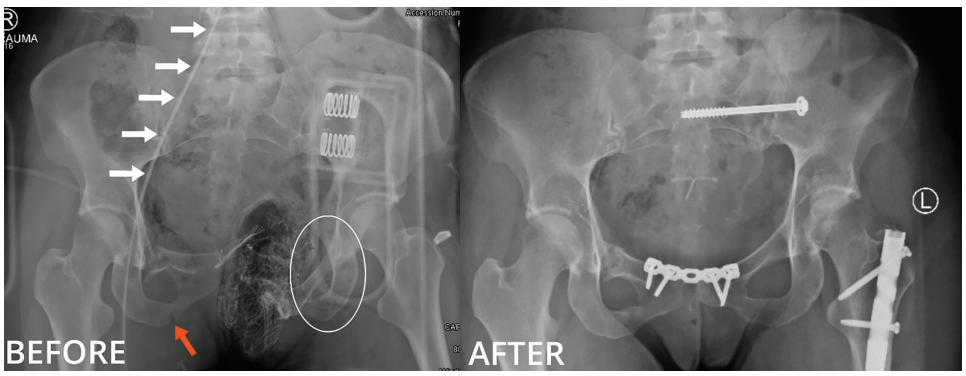

Figure 4 Orthopedic recovery.
AP pelvic X-Ray hours after the collision (left) and 6-months afterward (right). The five white arrows point to REBOA ascending the common iliac artery. The orange arrow points to a fracture of the right inferior pubic ramus. The white circle shows a left open book pelvic fracture. Corrections include a left sacroiliac screw, pubic symphysis plates, and an intramedullary nail fixation of the left femur.

The patient has had a remarkable recovery. Multiple consults with orthopedics in the following year ensured proper bone alignment (Figure 4) and a colostomy takedown greatly improved her quality of life. She came to the emergency room 2 months post-accident with an isolated DVT that was managed by switching from enoxaparin to rivaroxaban, which can be taken orally, while retaining the use of 325 mg of aspirin per CHEST guidelines [9]. She later returned for 5 days as an inpatient for thrombocytopenia which resulted in profuse vaginal bleeding and anemia. She received six units of packed red blood cells, three units of fresh frozen plasma, two units of platelets, and medroxyprogesterone as well as misoprostol to induce uterine contractions, expel uterine clots, and reduce bleeding. Rivaroxaban use was then contraindicated and suspended thereafter. Given persistent hemorrhaging and an unstable status, the patient underwent uterine artery embolization which significantly reduced further bleeding. She is back at work with no neurological deficits. However, she continues to be followed up for recurrent urinary tract infections, dyspareunia, and urge incontinence.

DISCUSSION

The efficacy and practicality of REBOA is complex given that patients present with significant variabilities in trauma localization and hemodynamic stability.

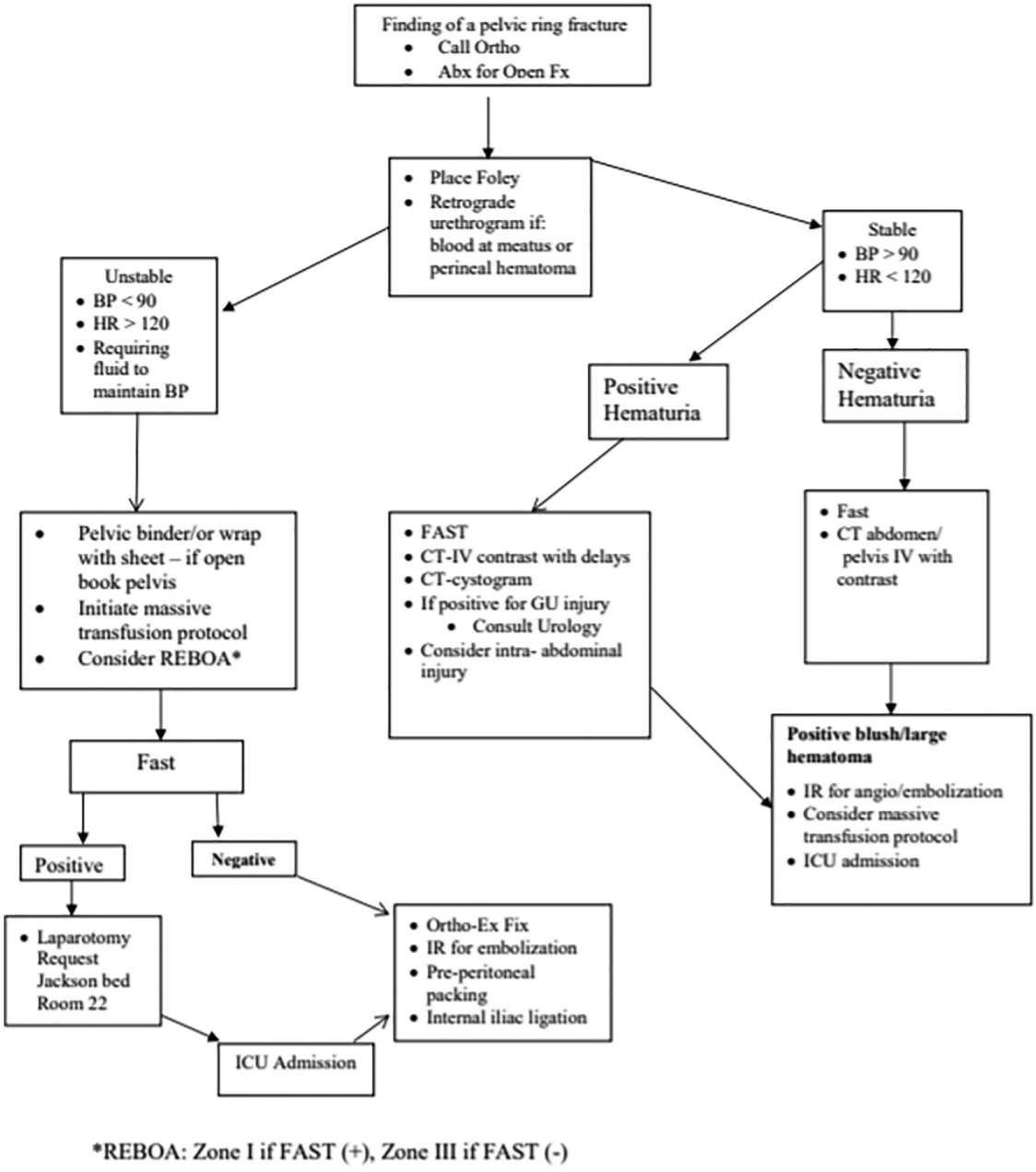

Figure 5 Institutional pelvic fracture management guidelines.

Trauma surgeons are often equipped with institutional algorithms that discern when REBOA insertion is optimal. At our institution, hemodynamic status, hematuria, and FAST results determine bifurcations in the decision management tree (Figure 5). If such factors compel REBOA use, a subsequent algorithm determines which zone REBOA should be employed (Figure 6). This algorithm contraindicates REBOA use if there is suspicion of aortic injury on chest X-ray.

Localization of trauma has a significant weight on REBOA's potential for success and complications. Bellal et al. argue that REBOA use is associated with higher mortality rates, lower extremity amputations, and acute kidney injuries, calling for clearer definitions of who benefits from REBOA [10]. This is partially due to where the trauma occurs. Thoracic trauma, such as injuries to thoracic veins or the subclavian arteries, is far less amenable to survival since zone 1 inflation occludes the renal arteries, superior mesenteric artery, and celiac trunk downstream. This lack of visceral blood flow is potentially lethal as it risks significant renal and gastrointestinal ischemia. For the same reason, those with pelvic hemorrhages are better suited for REBOA since these vascular branches are not obstructed by REBOA.

In a joint statement by the American College of Surgeons Committee on Trauma and the American College of Emergency Physicians, the consensus was reached that there is no high-grade evidence that REBOA outperforms the current standard of care. Moreover, level 1 trauma centers possess the lion's share of REBOAs, holding 87% of the devices in the US [4]. This makes it difficult to extrapolate REBOA's efficiency to lower-level trauma centers which are unequipped, in resources and expertise, to match the successful outcomes of larger institutions [11]. Level 1 institutions can provide total care to every aspect of injury whereas level 2 centers are able to initiate definitive care but may need to refer patients to level 1 centers which have more specialists and upgraded technology. Further studies examining the clinical utility and generalizability of REBOA are warranted.

We present a patient's 1-year post-operative recovery where the trauma was largely localized to the abdomen and pelvis. Uchino et al. describe an 86-year-old, hypotensive female who also sustained pelvic fractures from a vehicle collision [12]. However, instead of normalizing the patient's blood pressure, REBOA overshot considerably, reaching a systolic blood pressure of 180 mm Hg [12]. They theorize this exacerbated her intracranial

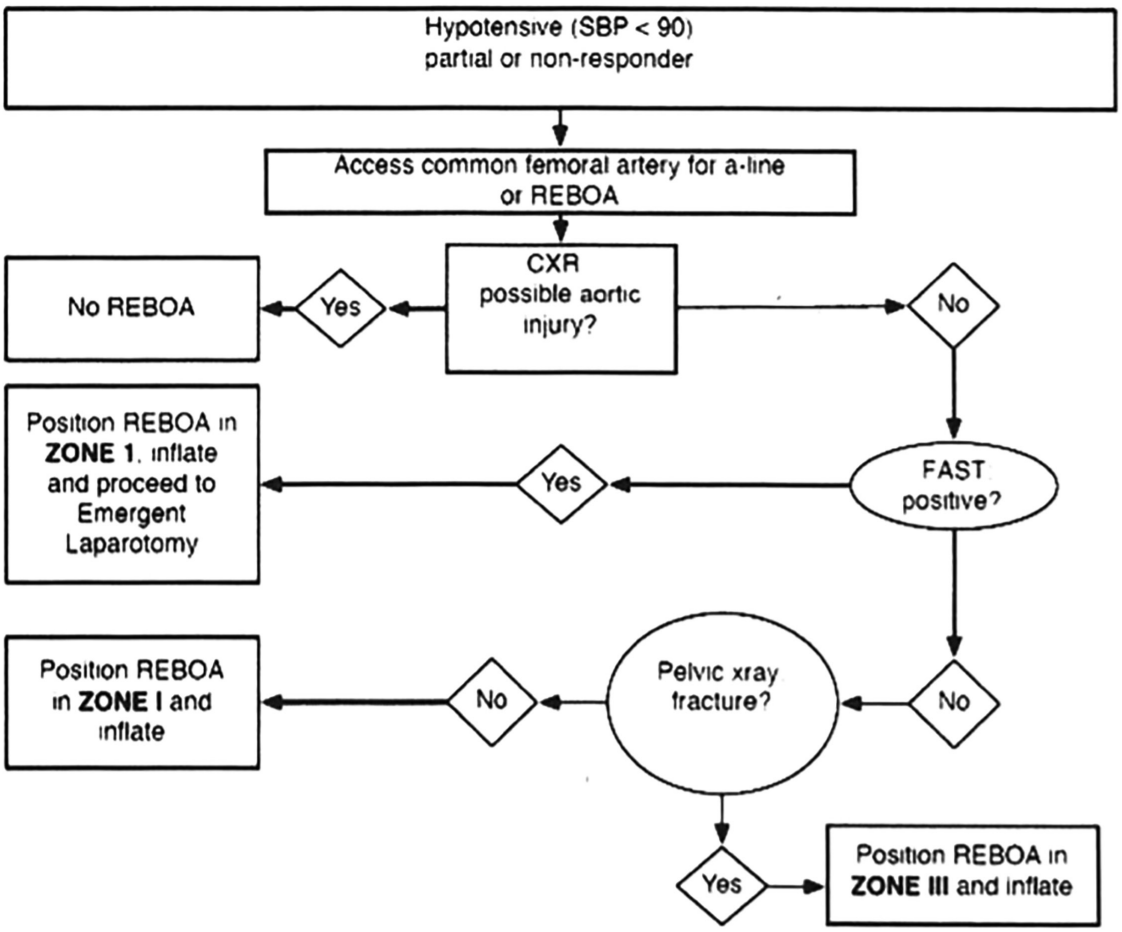

Figure 6 Institutional REBOA employment guidelines.

hemorrhaging which later led to cerebral herniation and death [12]. Rich et al. report the use of a roadside REBOA on a 23-year-old female complicated by left lower limb amputation [13]. They describe no further than 6-weeks of rehabilitative progress, during which only mild improvements were noted [13]. A right thigh seroma developed simultaneously, requiring three separate procedures to debride the wound and vacuum the fluid [13]. This greatly delayed the patient's rehabilitation [13]. In our case, REBOA induced no known long-term complications. A pseudoaneurysm did develop in the external iliac artery but likely emerged from trauma or endovascular access to the femoral artery since pseudoaneurysm development is seldom caused by REBOA [14]. Most pseudoaneurysms are iatrogenic [15]. The patient continues to be followed up for minor trauma and medication-induced complications.

CONCLUSION

This case demonstrates an exceptionally successful recovery from pelvic trauma using REBOA in a rural hospital. Exsanguination is difficult to control and is of foremost importance for life-threatening cases. REBOA can induce favorable results when applied to serious non-compressible pelvic hemorrhages.

Ethics Statement

(1) All the authors mentioned in the manuscript have agreed to authorship, read and approved the manuscript, and given consent for submission and subsequent publication of the manuscript.
(2) The authors declare that they have read and abided by the JEVTM statement of ethical standards including rules of informed consent and ethical committee approval as stated in the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Author Contributions

All authors have made substantial contributions to this manuscript.

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