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## Clinical paper

### Resuscitative endovascular balloon occlusion of the aorta (REBOA) in the pre-hospital setting: An additional resuscitation option for uncontrolled catastrophic haemorrhage<sup>☆</sup>

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#### ABSTRACT

This report describes the first use of Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) in the pre-hospital setting to control catastrophic haemorrhage. The patient, who had fallen 15 meters, suffered catastrophic internal haemorrhage associated with a pelvic fracture. He was treated by London's Air Ambulance's Physician-Paramedic team. This included insertion of a REBOA balloon catheter at the scene to control likely fatal exsanguination. The patient survived transfer to hospital, emergency angio-embolization and subsequent surgery. He was discharged neurologically normal after 52 days and went on to make a full recovery. The poor prognosis in catastrophic torso haemorrhage and novel endovascular methods of haemorrhage control are discussed. Also the challenges of Pre-Hospital REBOA are discussed together with the training and governance required for a safe system.

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#### Introduction

This case report describes the first use known to the authors of Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) in the pre-hospital setting for uncontrolled haemorrhage. London's

Air Ambulance (LAA) is a prehospital physician-paramedic trauma service that operates from an urban major trauma centre. The aim of the service is to provide rapid, effective treatment to seriously injured patients as soon as possible after injury. The medical team is trained in advanced pre-hospital procedures including rapid sequence intubation and pre-hospital thoracotomy.

#### Background

Non-compressible torso haemorrhage (NCTH) is the leading cause of preventable trauma deaths.<sup>1</sup> Pelvic fractures and

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junctional vascular injuries are two important sources of NCTH and are particularly challenging to manage. These injuries are associated with rapid exsanguination with mortality rates approaching 50 percent.<sup>2,3</sup> Even in well developed trauma systems, up to half of these deaths occur pre-hospital, or soon after arrival in hospital, before any opportunities for definitive haemorrhage control.<sup>2,3</sup>

For meaningful reductions in mortality, novel methods of early haemorrhage control are needed. Temporary balloon occlusion of the aorta is a standard technique used to control haemorrhage in patients with ruptured aortic aneurysms.<sup>4,5</sup> This technique has also been used to control other causes of non-compressible haemorrhage including gastro-intestinal haemorrhage, post-partum haemorrhage, and trauma.<sup>6</sup>

We established a multidisciplinary working group to investigate the possible role of REBOA as a temporizing pre-hospital intervention to enable more patients with these injuries to survive to definitive care. The group consisted of clinicians from pre-hospital care, emergency medicine, trauma surgery, interventional radiology, anaesthesia, and intensive care medicine. A protocol for pre-hospital REBOA was produced along with a structured training, education, and governance programme.<sup>7</sup>

The group identified a cohort of patients who were at high risk of death through exsanguination from pelvic injuries who would be suitable for distal aortic (zone 3) REBOA. A Standard Operating Procedure was developed which defined the indications for zone 3 REBOA as:

Shocked adults with non-compressible exsanguinating haemorrhage from:

- blunt or penetrating pelvic injury or
- junctional vascular groin injury

### Summary of case

In May 2014 LAA was tasked to a severely injured 32-year-old male who had fallen approximately 15 m landing on concrete. The doctor-paramedic team arrived 34 min after the injury.

Their primary survey examination revealed a patent airway, tachypnoea (30 breaths/min), and profound shock. The patient was pale and sweaty, tachycardic (130 bpm) with delayed capillary refill, weak carotid pulse and no recordable blood pressure. He was drowsy but responsive to voice. Examination of his head, chest and abdomen were grossly normal. He had a deformed pelvis, and fractures of both ankles.

The pelvis was splinted and intravenous crystalloid administered while an emergency pre-hospital blood transfusion was prepared. Rapid Sequence Induction of anaesthesia was performed, the airway secured with a tracheal tube and positive pressure ventilation commenced.

Exsanguinating haemorrhage secondary to the pelvic fracture was suspected. The estimated time to the closest Major Trauma Centre was approximately 30 min and the treating team did not believe the patient would survive the transfer. A decision was made to perform REBOA. Under ultrasound guidance, an 8Fr sheath (Cordis, California) was placed in the right femoral artery using a Seldinger technique. A 14 mm 7Fr embolectomy balloon catheter (LeMaitre, Massachusetts) was inserted through the sheath to a depth of 40 cm and inflated with 2 ml of saline. The catheter was then allowed to migrate distally, under aortic pressure, and came to rest 25 cm from the insertion point. This is our standard technique for placing a balloon at the aortic bifurcation.

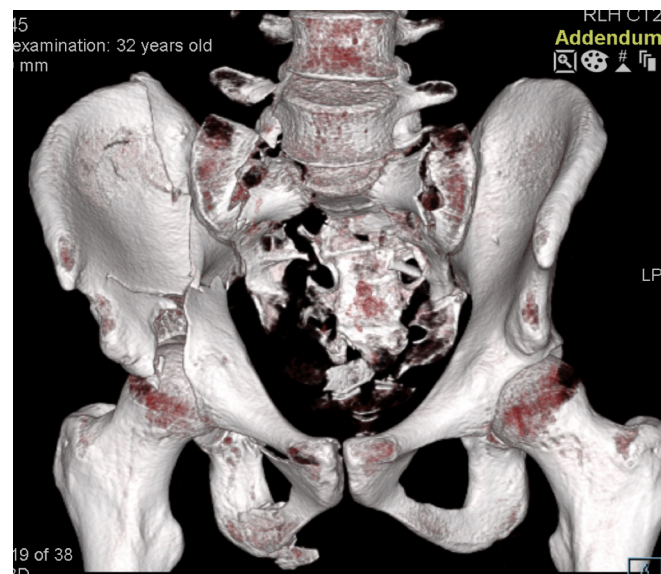
Central perfusion improved following balloon inflation and NIBP was measured at 82/56 mmHg. In total, 250 ml of 0.9% saline and six units of Packed Red Blood Cells (PRBC) were transfused prior

**Table 1**  
Injuries sustained in each body region with the corresponding highest Abbreviated Injury Scale (AIS) score.<sup>20</sup> The calculated Injury Severity Score (ISS) was 45.<sup>21</sup>

Body region	Identified injuries	AIS score
Head and neck	None	0
Face	Left orbital floor fracture.	2
Thorax	Right 4th–6th rib fractures. Left 6th–8th rib fractures. Left small haemo-pneumothorax. Left lung contusion. Dissection injury of descending aorta distal to the origin of the left subclavian artery with contained mediastinal haematoma.	4
Abdomen	2nd–5th Lumbar vertebrae transverse process fractures.	2
Pelvis and Extremities	Right iliac blade fracture extending into right sacroiliac joint. Bilateral inferior pubic rami fractures. Bilateral sacral ala fractures involving S1–3 sacral foramina. Comminuted fracture of the coccyx. Right acetabular fracture. Large retroperitoneal haematoma.	5

to arrival in the Emergency Department. One gram of Tranexamic Acid was also administered prior to arrival at hospital.

On arrival at the major trauma centre the patient had a heart rate of 130 and a blood pressure of 88/46. Blood gas analysis revealed a marked metabolic acidosis with pH 6.94, lactate 7.8, and base deficit of -16.7. The patient underwent a FAST scan that was negative, a pelvic X ray showing a vertical shear pelvic fracture and a chest X ray showing a widened mediastinum. This was followed by whole body CT scan that confirmed pelvic injuries and also an aortic injury (Table 1 and Fig. 1). The CT also confirmed correct positioning of the REBOA balloon at the aortic bifurcation (Fig. 2). The patient was moved directly to the Interventional Radiology suite where the REBOA balloon was deflated to allow visualization and cannulation of the contralateral common femoral artery. The patient did not experience any marked haemodynamic deterioration after balloon deflation. Angiography identified multiple sites of active haemorrhage from both internal iliac arteries and a contained dissection of the proximal descending thoracic aorta. The internal iliac arteries were embolized with gelfoam and a stent graft was positioned across the aortic dissection. The patient was



**Fig. 1.** Computer tomography reconstruction of the pelvic injury.

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