

# Balloon Expandable Covered Stent in a Child with Traumatic Aortic Rupture

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**T**rauma is the leading cause of morbidity and mortality in children. Although blunt aortic injury is uncommon, it is the second leading cause of death, after head injury, in the pediatric trauma population. Undiagnosed aortic trauma significantly increases the risk of in-hospital mortality [1]. Reduction of post-hospital death caused by aortic tear requires a high level of suspicion, a systematic diagnostic approach, and an understanding of the pathology of acute traumatic aortic tear (ATAT) [2].

In the last decade there has been a transition in the therapeutic approach from open surgical repair to endovascular repair [1,3]. However, in children, this procedure is still debatable due to the anatomic differences between adults and children. These differences include the caliber of the access vessel (usually the femoral artery), a relatively smaller aortic diameter, the growing thoracic aorta, and the long-term side effects and durability of the repair.

In this case report we describe our successful experience with balloon expandable endovascular repair of ATAT in a 12 year old female and the 3 year follow-up after her repair.

## PATIENT DESCRIPTION

A 12 year old girl was injured as a pedestrian in a high-speed motor vehicle colli-

sion. In the field she had a Glasgow Coma Scale of 6. She was intubated and ventilated and her cervical spine was immobilized. She was brought to the emergency department of a level 1 trauma center.

At arrival, her vital signs showed a heart rate of 153 beats per minute, blood pressure 69/35 mmHg, and saturation of 93% on FiO<sub>2</sub> of 1.0. Physical examination revealed an unconscious, ventilated child with a deep scalp laceration and no other external physical findings. In the trauma bay her condition was stabilized according to the advanced trauma life support protocol. Chest X-ray [Figure 1A] showed a left pulmonary contusion and widened mediastinum. A computed tomography (CT) scan showed multiple brain punctuate hemorrhages diagnosed as diffuse axonal injury, grade 1 spleen and left renal lacerations, and fractures of the left humerus and the pelvis. There were no rib fractures. Chest CT angiography (CTA) demonstrated an aortic injury near the aortic isthmus 2 cm distal to the left subclavian artery with extravasation of contrast material and with superior mediastinal hematoma and lung effusion [Figure 1B, 1C] confirming the diagnosis of traumatic aortic tear. Descending thoracic aortic diameter was measured as 12 mm at the level of the injury (normal adult size is 24 ± 3 mm).

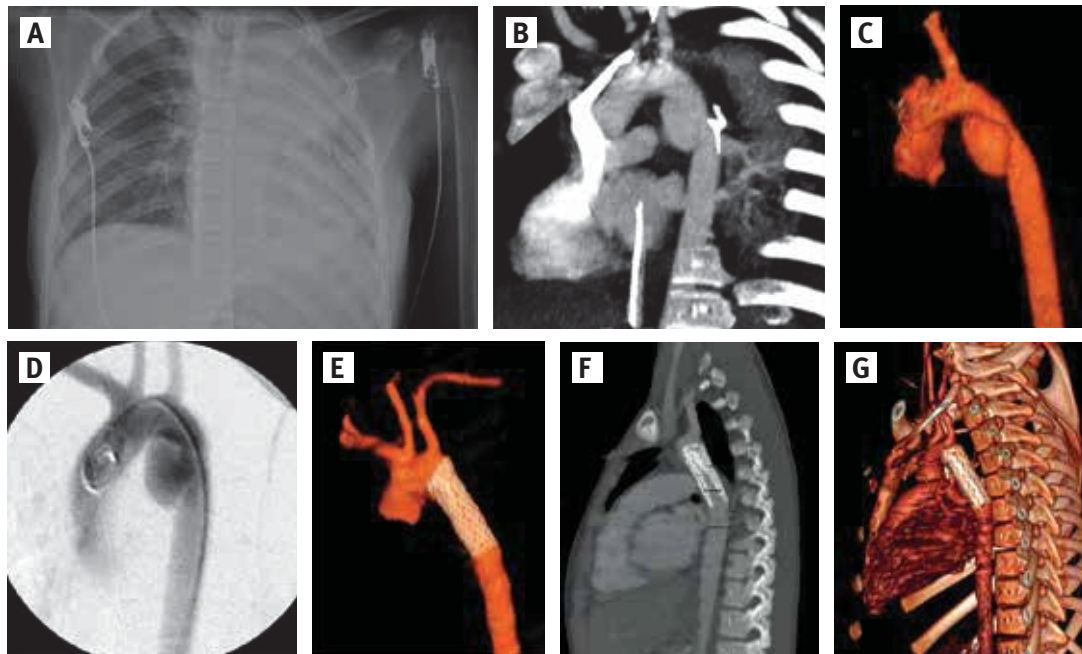
Her other injuries did not call for operative intervention and therefore the girl was admitted to the pediatric intensive care unit (PICU) to stabilize her condition until a specialized, pediatric compatible, stent graft that fit the size of her aorta could be obtained. In the PICU, a radial arterial line was inserted and the systolic blood pressure

was maintained less than 90 mmHg with the use of sedation. At the time there was no need to add beta-blockers. Within 2 hours, a stent was brought to the hospital and the patient was transferred to the operating room. A surgical technique using an Atrium iCast™ covered stent (Atrium Maquet Getinge Group, Germany) was chosen because of her small access femoral arteries and her small aortic diameter [Figure 1D]. The adult conventional nitinol (nickel-titanium) self-expanding stents need a much wider access artery than our patient had. Using a left femoral artery approach, the stent was deployed just distal to the left subclavian artery, achieving a complete occlusion of the tear. The total length of thoracic aorta covered was 5 cm. Due to multiple focal head hemorrhages, systemic heparinization or anti-aggregation posed a possible major risk of bleeding.

Our institutional approach in such cases is not to use systemic heparinization but rather to use heparin flush of the endovascular catheters and devices with a heparin solution concentration of 500/100 units/ml. No further anticoagulation or platelet anti-aggregation was used in this patient. There were no intra-operative or postoperative complications. The time from the injury to definitive repair was 5 hours and 40 minutes, including the operation time of 1 hour and 40 minutes.

The patient spent a total of 10 days in the PICU and 6 more days in the pediatric surgical ward. Although the patient had complete and satisfactory recovery from the endovascular repair, her PICU length of stay was due to her brain, intra-abdominal, and pulmonary injuries, which required intubation and ventilation for 4 additional days.

**Figure 1.** [A] The first chest X-ray in the trauma room reveals a dense consolidation in the left upper lobe which was due to right mainstream intubation, [B] Sagittal computed tomography (CT) reconstruction shows the pseudo aneurysm at the point of the tear, [C] Multiplanar reconstruction (MPR) before the operation showing the pseudo aneurysm at the point of the tear, [D] Angiography after catheterization proximal to the tear bed, [E] MPR after stent graft insertion below the origin of subclavian artery without evidence of leak, [F] A-Sagittal CT reconstruction, [G] MPR 3 years later showing stent patency with a 20% difference between the aortic and stent diameter



A repeat CTA [Figure 1E] was performed before discharge from the hospital. It showed good resolution of the aortic injury, no positional malalignment of the covered stent, and no leakage from the traumatized area. Her head CT was read as normal at hospital discharge.

The girl was transferred to a rehabilitation center. Three months after the accident, she was fully conscious and doing well. Since the accident she has been followed yearly in the endovascular surgical clinic. Three years post-injury her physical examination was normal with no difference in blood pressure between the upper and lower extremities. A follow-up CT scan of the chest revealed stent patency with an insignificant clinical diameter difference of 20% between the aorta and stent [Figure 1F, 1G]. We will continue to monitor her during follow-up visits and the stent will be expanded in the future if clinically recommended.

### COMMENT

We describe an uncommon trauma case and successful innovative treatment of a pediatric aortic tear. Aortic rupture is a devastating injury and most patients will

die at the scene or shortly after arrival at the hospital. If the patient reaches the hospital alive, the risk of rupture is rather low. In that situation, most probably there is an aortic tear and the continuity of the injured aorta is maintained by the adventitia and the surrounding mediastinal structures.

Incidence of ATAT is approximately 0.06% in children admitted to the hospital after nonspecific blunt trauma and in about 7.4% of children admitted with severe blunt chest injury [4]. ATAT requires significant force from rapid deceleration, usually due to motor vehicle accidents, and consequently it is usually associated with other injuries, mainly cerebral lesions, lung contusion, rib fractures, abdominal visceral lacerations, and orthopedic trauma [5].

As in our case, the most frequent anatomical position of ATAT (55–67%) is at the isthmus of the descending thoracic aorta, where the relatively immobile descending aorta, held by the ligamentum arteriosum, and overlying mediastinal pleura, decelerates at a different speed compared with the fairly mobile heart and aortic arch [5].

Once the suspicion of ATAT is raised (due to mechanism of injury or chest

X-ray), it is imperative to reveal or exclude the diagnosis. Angiogram, CTA, or transesophageal echocardiography are the most common methods, with the decision to use one over the other dependent on institutional experience and availability.

Until definitive repair, the patient should be kept relatively hypotensive to reduce the risk of complete aortic rupture, which might lead to exsanguination [1,5]. The reason for permissive hypotension is to reduce the shear forces, minimizing the risk of rupture prior to repair. In our case the patient was given analgesia and sedation with fentanyl and midazolam, which lowered her blood pressure to our goal of less than 90 mmHg systolic.

Recent studies in adult patients indicate that endovascular treatment of descending thoracic aortic trauma is a good alternative to open surgical repair and is associated with lower postoperative mortality, lower transfusion requirements, and less ischemia time of the spinal cord [5]. Advantages of endovascular treatment also include avoidance of thoracotomy, single-lung ventilation, aortic cross-clamping, left heart or cardiopulmonary bypass, spinal cord ischemia, and renal insults secondary to hypoperfu-

sion. The technique requires considerably less time and can be done expeditiously in relatively unstable patients, as most ATAT patients are.

Over the past 2 decades, the endovascular approach for adolescent traumatic aortic rupture patients has become available, especially in multitrauma patients similar to ours with traumatic brain injury who are at high risk of systemic anticoagulation, which is mandatory for open surgical repair using cardiopulmonary bypass machine [4]. In pediatric patients, open repair either with primary anastomosis or placement of synthetic grafts is currently still the standard of care because not all trauma centers treat children and the implantation of such devices needs the availability of small diameter stents together with highly skilled personnel who can safely perform the procedure.

Most major hospitals have cardiothoracic surgery departments with in-house available teams that are skilled in open repair. In our patient, the in-house availability of a skilled endovascular team, the easily accessible specialized endovascular device, and the presence of relative contraindication of anticoagulation and bypass made her a good candidate for such repair. There are reports, and recently a longitudinal study [1], that shows the evolution and transition of treatment from an open approach (prior to 2008) to an endovascular approach, with very promising results [1,4].

The decision to choose Atrium's 16 mm iCAST endovascular device was due to its small diameter that could fit a small 12 year old female femoral access vessel as well as the ability to expand it to her 12 mm diameter aorta.

The difference found between aorta and stent diameter at 3 years follow-up is not surprising. The aorta dilates as children grow and even thereafter with age. Long-term follow-up of patients after endovascular repair for ATAT showed proximal and distal dilatation of aorta especially in the younger age group (< 30 years old) [2]; therefore, the dilatation observed in our case is likely related to the natural history of the thoracic aorta.

In contrast, dilatation of an aortic aneurysm is pathologic and carries the risk of endoleak. The use of a balloon expandable covered stents for ATAT in children, as done in this case, demonstrates two advantages of the Atrium covered stent compared to the ordinary self-expandable stent-grafts: first, the much smaller delivery system, which is more suitable to use in children, and second, the possibility to further dilate the covered stent as the child grows. In case the narrowed stent will need further expansion, it will probably be treated in a similar approach as coarctation.

**CONCLUSIONS**

The low incidence of traumatic aortic injuries can make recognition difficult. Cases,

as the one described here, are important to publicize in order to increase the awareness of this situation and to be cognizant of it in cases of blunt thoracic trauma. Endovascular treatment for ATAT can be logistically as well as technically challenging, requiring expeditious imaging and personnel trained in endovascular procedures. Nevertheless, it is a promising technique with good results and outcomes. For a hospital to be ready for such a case, an assortment of endografts and stents must be available at any given time.

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**Capsule**

**High adherence to system-level performance measures for rheumatoid arthritis in a national early arthritis cohort over 8 years**

**Barber** et al. tried to assess adherence to 3 system-level performance measures in a national early rheumatoid arthritis (RA) cohort. A total of 1763 early RA patients were included (mean age 54 years, 73% female, 82% Caucasian). At enrollment, mean ± SD disease duration was 6 ± 3 months, and Disease Activity Score in 28 joints was 5.1 ± 1.5. Over 8 years, the proportion of patients seen in annual follow-up declined from 100% to 91%. At follow-up, 42% of patients had no gaps in care of > 12 months, and 64% had no gaps > 14 months. The percentage of disease-modifying antirheumatic drugs (DMARDs)-treated early RA patients remained high (95–87%),

and the percentage receiving DMARDs within 14 days of diagnosis was 75%. Median time-to-DMARD therapy was 1 day, indicating DMARDs were initiated at diagnosis (90th percentile 93 days). There was evidence of high adherence to system-level performance measures in this early RA cohort following a protocol. Small declines in performance were noted with increasing length of patient follow-up. These findings are useful for performance measure benchmarking.

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