

# Angiographic Embolization in Pediatric Abdominal Trauma

Yechiel Sweed MD<sup>1,2</sup>, Jonathan Singer-Jordan MD<sup>2,3</sup>, Sorin Papura MD<sup>2,3</sup>, Norman Loberant MD<sup>2,4</sup> and Alon Yulevich MD<sup>1,2</sup>

Departments of <sup>1</sup>Pediatric Surgery, <sup>2</sup>Interventional Radiology and <sup>3</sup>Radiology, Galilee Medical Center, Nahariya, Israel

<sup>4</sup>Faculty of Medicine in the Galilee, Bar-Ilan University, Safed, Israel

**ABSTRACT:** **Background:** Trauma is the leading cause of childhood morbidity and mortality. Abdominal bleeding is one of the common causes of mortality due to trauma. Angiography and embolization are well recognized as the primary treatments in certain cases of acute traumatic hemorrhage in adults; however, evidence is lacking in the pediatric population.

**Objectives:** To assess the safety and efficacy of transcatheter arterial embolization (TAE) for blunt and penetrating abdominal and pelvic trauma in the pediatric age group.

**Methods:** Three children with blunt abdominal trauma and one child with iatrogenic renal injury (age 4–13 years) were managed with TAE for lacerated liver (one patient), pelvic fractures (one patient) and renal injuries (two patients). The first two patients, victims of road accidents, had multisystem injuries and were treated by emergency embolization after fluid resuscitation in the Emergency Department (ED). The other two patients had renal injuries: a 4 year old boy with blunt abdominal trauma was diagnosed on initial computed tomography with an unexpected Wilms tumor and was treated with embolization 1 day after admission due to hemodynamic deterioration caused by active arterial tumor bleeding. The following day he underwent successful nephrectomy. The other patient was 13 year old boy with nephrotic syndrome who underwent renal biopsy and developed hemodynamic instability. After fluid resuscitation, he underwent an initial negative angiography, but second-look angiography the following day revealed active bleeding from an aberrant renal artery, which was then successfully embolized.

**Results:** In all four patients, TAE was diagnostic as well as therapeutic, and no child required surgical intervention for control of bleeding.

**Conclusions:** We propose that emergency transcatheter angiography and arterial embolization be considered following resuscitation in the ED as initial treatment in children with ongoing bleeding after blunt abdominal trauma or iatrogenic renal injury. Implementation of this policy demands availability and cooperation of the interventional radiology services.

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**KEY WORDS:** angiography, embolization, abdominal trauma, bleeding, resuscitation, Wilms tumor

For more than 40 years trauma has been considered the leading cause of childhood death (age < 18 years), with an annual mortality that is continuously increasing [1,2]. Ninety percent of childhood injuries are associated with blunt trauma, with head and limb injuries being the most common forms. Abdominal trauma in up to 8% of these severe cases includes primarily solid organs (ASO), liver, spleen and kidney involvement [3]. The spleen is the most commonly injured intraabdominal organ. Injuries to the liver, spleen and pancreas occur in two typical scenarios: isolated injury caused by a direct blow to the upper abdomen, or multisystem trauma caused by high energy mechanisms (e.g., motor vehicle or all-terrain vehicle crash, fall from a great height) [4].

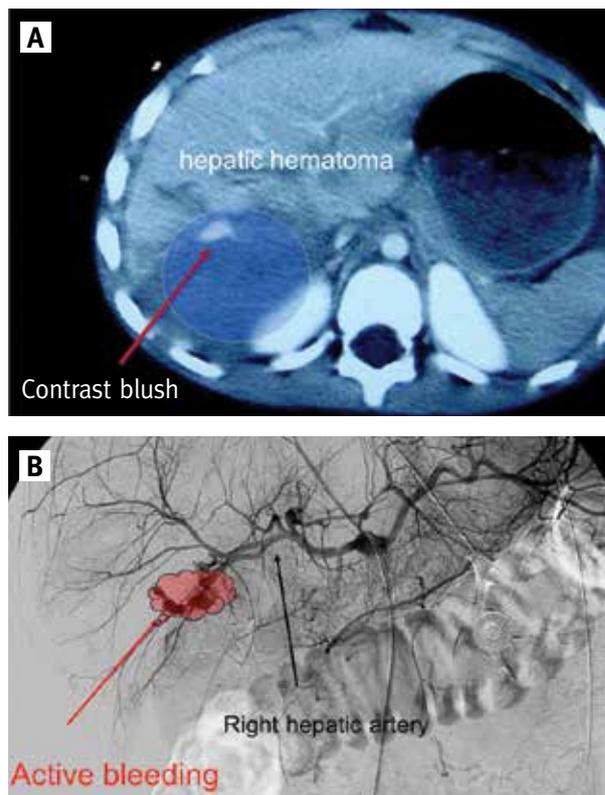
In the adult population, liver, splenic, renal and pelvic arterial embolization (AE) was introduced to achieve organ preservation in injured patients who would traditionally have undergone organ dissection [5]. Pediatric experience with AE for blunt ASO injuries is limited [6,7]. Most children with solid organ injuries are managed in accordance with the NOM protocol; this includes observation and blood transfusion, which although uncommon, is the most frequent therapeutic intervention. Angiographic embolization and laparotomy are infrequently performed [8].

We present four pediatric trauma patients in which transcatheter arterial embolization (TAE) was performed to determine the efficacy and safety of this non-surgical management. TAE was performed in pediatric patients with blunt multiple trauma (three patients) and penetrating injury (one patient) who transiently responded to the initial fluid resuscitation.

## PATIENT DESCRIPTIONS

Three children with blunt abdominal trauma and one child with iatrogenic renal injury (ages 4–13 years) were managed with TAE for lacerated liver (one patient), pelvic fracture (one patient) and renal injuries (two patients). The first two patients, victims of road accidents, were resuscitated in the ER. The other two patients had renal injuries: a 4 year old boy with blunt abdominal trauma was diagnosed on initial computed tomography (CT) with an unexpected Wilms tumor and was treated with embolization for an arterial tumor bleeding. The following day he underwent successful nephrectomy. The other patient, a 13 year old boy with

**Figure 1.** A 5 year old boy after a car accident. **[A]** CT angiogram shows contrast blush within the liver. **[B]** Selective angiogram shows contrast extravasation indicating active bleeding



nephrotic syndrome, underwent renal biopsy and developed hemodynamic instability. He underwent an initial negative angiography, but second-look angiography the following day revealed active bleeding from an aberrant renal artery, which was then successfully embolized.

#### PATIENT 1

A 5 year old boy arrived at the ED after being hit by a car while crossing the road. His vital signs were: Glasgow Coma Scale (GCS) 15, heart rate 160–170/min, blood pressure 140/75 and 100% saturation. A scalp laceration and fracture of the left humerus were diagnosed. Chest X-ray demonstrated bilateral pneumothorax and bilateral lung contusions with a fracture of the right clavicle. On arrival he was treated with fluid resuscitation, placement of two chest tube drains and tracheal intubation. Focused abdominal sonography (FAST) examination showed fluid in the abdominal cavity. Head CT was normal without skull fracture or intracranial bleeding. Abdominal CT showed active liver bleeding with associated hematoma of the right hepatic lobe. Figure 1A demonstrates contrast blush on CT angiography in an actively bleeding branch of the right hepatic artery; Figure 1B shows the bleeding on conventional selective hepatic angiography.

After the successful angiography and embolization, his scalp laceration was sutured and the arm fracture was reduced. The boy was released home in good condition after 1 week of hospitalization.

#### PATIENT 2

A 4½ year old boy arrived at the emergency room after an abdominal injury as a result of a fall. His vital signs were pulse 130/min, saturation 98% and GCS 15. His physical examination demonstrated a slightly swollen abdomen. His left upper abdomen was sensitive to palpation, suspicious for splenic injury. However, abdominal CT demonstrated a neoplastic mass emerging from the left kidney. The mass was 15 cm in diameter and suspicious for Wilms tumor.

Pathological blood vessels were seen covering the tumor; in addition, some pelvic fluid was also detected. Subsequent to the abdominal tumor diagnosis, the child was admitted to our pediatric surgical department. On the following day he developed pallor and tachycardia. Intravenous fluid and blood transfusion were administered, and he was sent for repeat abdominal CT, including CT angiography. Using this approach, active tumor bleeding was identified. Figure 2 demonstrates the findings of the second abdominal CT. Figure 2A and 2B show the contrast blush in both transverse and coronal planes. Figure 2C demonstrates a selective left renal arteriogram that pinpointed the actively bleeding vessels. Following the diagnosis of active bleeding, percutaneous selective catheter insertion was used for arterial embolization. The following day the child was hemo-



**Figure 2.** A 4½ year old boy after a fall. **[A]** Axial image from abdominal CT scan following a day of hospitalization and **[B]** coronal reconstruction both demonstrate a contrast blush in the left upper abdomen indicating active bleeding. **[C]** Selective left renal arteriogram identified active bleeding foci

dynamically stable and on the second post-embolization day he underwent left nephrectomy combined with placement of Port-A-Cath for chemotherapy treatment.

The child successfully completed the chemotherapy and radiotherapy protocol. On our last follow-up exam, 6 years after surgery, he was in good condition.

**PATIENT 3**

A 13 year old boy, who had previously been diagnosed with nephrotic syndrome, arrived at the emergency room complaining of abdominal pain. The child's renal function progressively deteriorated and he began to suffer from anuria. He underwent a renal biopsy which was followed by hemodynamic and respiratory deterioration. In addition, his hemoglobin values were decreased. Abdominal ultrasound followed by abdominal CT demonstrated a large left retroperitoneal hematoma. No active bleeding had been recognized at this stage. After 48 hours of hospitalization the patient's clinical condition further deteriorated including tachycardia and a decrease in hemoglobin levels. To determine the reason for this clinical picture it was decided to perform second-look angiography, which showed that the recognized retroperitoneal hematoma diameter had increased. In a selective arteriogram of the third aberrant left renal artery, active bleeding was detected. Figure 3 demonstrates the retroperitoneal hematoma and the selective angiogram of the aberrant renal artery, showing contrast extravasation. The hemodynamic condition of the child was stabilized. Following the angiographic embolization, the diagnosed large abdominal hematoma gradually began to shrink.

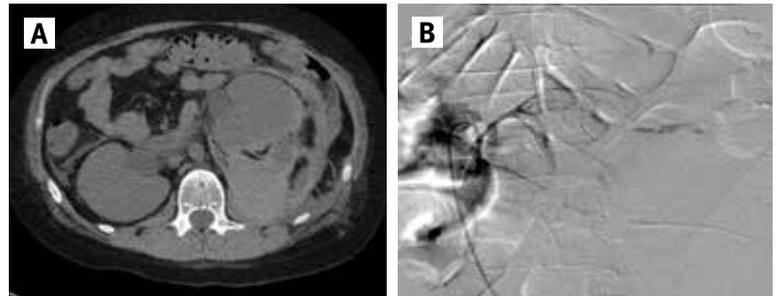
**PATIENT 4**

An injured 10 year old girl arrived at the emergency room after being hit by a car while walking. Her vital signs were GCS 15, pulse 136/min, blood pressure 130/86, and 100% saturation. A hematoma of the left pelvis and vaginal bleeding had been noticed during physical examination. Her neck and chest X-ray were normal but pelvic X-ray confirmed pelvic fractures. Abdominal CT demonstrated several injuries: left kidney contusion, retroperitoneal hematoma, pelvic fractures, and bilateral ramus pubis and sacro-iliac joint fractures. In addition, active pelvic bleeding was diagnosed.

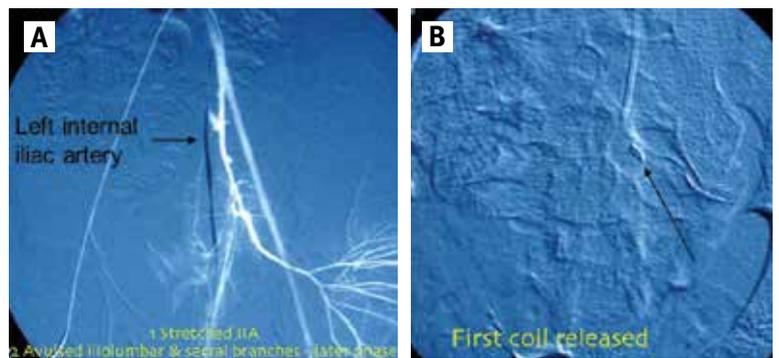
Initial emergency treatment included intravenous fluids and blood transfusion. Angiography of the left iliac artery showed active bleeding which was treated by embolization. In the selective angiogram of the left internal iliac artery [Figure 4] extravasation is seen; after embolization there was no extravasation.

After the angiographic embolization, the external pelvic fractures were stabilized. Her vaginal bleeding and tears in the vaginal wall were treated by packing. After hospitalization of 1 week she was discharged home in good condition.

**Figure 3.** A 13 year old boy with abdominal pain. **[A]** Axial abdominal CT scan shows a large left retroperitoneal hematoma. **[B]** Selective arteriogram of the aberrant renal artery shows contrast extravasation



**Figure 4.** A 10 year old girl after being hit by a car. Angiographic embolization of left internal iliac artery. **[A]** Selective left internal iliac artery angiogram shows extravasation of contrast. **[B]** After coil embolization there is no further extravasation



**DISCUSSION**

Angiography is a common treatment specifically used in adults with blunt abdominal trauma and/or severe pelvic fractures. The usefulness of such treatment in the pediatric trauma care setting is unclear. Recently, the Committee on Trauma of the American College of Surgeons advocated that angiography be urgently available at pediatric trauma centers. Angiography and embolization techniques are well described in arresting severe active bleeding in adults. CT angiography followed by catheter angiography is beneficial: it saves time, and enables precise identification of the injury locus and dimensions. The quicker these parameters are recognized and categorized, the quicker the health care personnel can plan an effective method to stop the bleeding. Such prompt and accurate treatment might constitute a lifesaving method in cases of severe bleeding.

The knowledge regarding pediatric treatment applying angiography and embolization for blunt ASO injuries is comparatively limited [8,9]. Skattum et al. [10] demonstrated improvement of non-operative management with splenic preservation from 90% to 98% with use of splenic angio-embolization. Kiankhooy and team [6] successfully treated seven children

with angio-embolization: three hepatic and four splenic. Interestingly, the average time from evaluation to embolization in this study was 11 hours. Vo et al. [9] demonstrated that hemorrhage due to pelvic fractures could successfully be managed with embolization.

Our purpose was to determine the efficacy and safety of angiography in the treatment of blunt abdominal trauma in injured children. This report described four cases of successful treatment for pediatric abdominal injuries using angiographic embolization. The age range of the described cases was 4.5–13 years old. In all four cases the use of angiography and embolization was found effective in three aspects: it is an improved diagnostic tool, an accurate treatment method, and an efficient treatment method. It was shown by us and others that the use of angiography embolization in the pediatric population leads to a favorable treatment outcome. In particular, it was shown that among patients who transiently respond to initial fluid resuscitation, transcatheter arterial embolization (TAE) was found valuable.

### CONCLUSIONS

We have presented four cases showing various scenarios of pediatric trauma and demonstrated that angiographic embolization can have tremendous value in stabilization and definitive treatment of serious trauma. We strongly believe that pediatric trauma surgeons as well as invasive radiologists should be able to treat children applying these techniques. It should be mentioned that the described method requires highly skilled personnel and adequate equipment availability around the clock in any trauma medical center. In addition, the success of this modality is based

on cooperation among the personnel of several departments and units, including pediatric surgery, interventional radiology, anesthesiology and pediatric intensive care.

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### Correspondence

#### Dr. Y. Sweed

Dept. of Pediatric Surgery, Galilee Medical Center, Nahariya 22100, Israel

**Phone:** (972-4) 910-7569

**Fax:** (972-4) 910-7645

**email:** yechiels@gmc.gov.il

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