Air Medical Journal 36 (2017) 151–155

Contents lists available at ScienceDirect

Air Medical Journal

journal homepage: http://www.airmedicaljournal.com/

Case Review

An 11-Year-Old Who Suffered Multiple Traumatic Injuries Secondary to a House Explosion

Michelle M. McLean, MD, EMT-P, Brad Demijohn, BS, RN, MS, Taylor Wallen, BS, MS, Peter V.R. Tilney, DO, FACEP, EMT-P

On a 40 degree late winter day, a house occupied by 5 children and 2 adults exploded secondary to a propane leak. The air medical helicopter was dispatched by ground emergency medical services to assist with patient transport to the appropriate trauma center. The initial dispatch information was for an injured child of 5 years of age requiring treatment and transfer. Upon arrival, the air medical team noted that the entire house was destroyed. The roof had collapsed with chunks of rubble that contained cement, wood, and drywall. Debris was found across the road and into the neighbor's yard. Firefighters and ground emergency medical service personnel were sifting through the rubble looking for a child who was still reported missing. Medical providers on scene alerted the air medical critical care team that the missing child had been located and his injuries were extensive. As it turns out, the team arrived to find an 11-year-old male who was moaning with obvious long bone fractures.

The Advanced Trauma Life Support (ATLS) primary survey was initiated. The airway was evaluated. The patient had burns to his face with singed hair. The paramedic did a jaw thrust to open the airway. There was soot and pooled secretions in his mouth. Because of the patient's inability to maintain his own airway, it was determined that rapid sequence induction for endotracheal intubation needed to be performed. Broselow Tape (eBroselow Products, Blacksburg, VA) was used, and the patient measured green (30-36 kg). The critical care crew elected to use ketamine 80 mg and rocuronium 40 mg. These medications were given intravenously per protocol. The paramedic used a video laryngoscope for intubation.

Upon initial insertion of the blade, the patient had copious amounts of blood and secretions in the oropharynx. Suction was used to clear the secretions, and the endotracheal tube was passed through the vocal cords. Initially, there was good compliance with bag valve mask ventilation. End-tidal carbon dioxide ($ETCO_2$) was initiated, and it was noted to be 4 to 6 mm Hg. Recognizing that this was significantly below normal, the team began to assess the situation. The critical care nurse verified peripheral pulses, and it was determined that perfusion was not the cause of the low $ETCO_2$ reading. The critical care paramedic deflated the balloon, and the endotracheal tube was removed. The endotracheal tube was placed a second time using a bougie with a video laryngoscope. A 6.5-mm endotracheal tube was placed at 20 cm at the lip. $ETCO_2$ measured 44 mm Hg, and oxygen saturations were 97%. The patient was placed on the ventilator in the assist control mode with the rate at 18. Fentanyl was provided for postintubation sedation. The positive end-expiratory pressure was set at 5 cm H_2O, and his tidal volume at 200 mL. Forty micrograms of fentanyl was provided for sedation intravenously. On further assessment, his breath sounds were diminished in both lung bases. There was no evidence of crepitus or flail chest. Peripheral pulses were intact; however, capillary refill was delayed at 4 seconds in the injured lower extremities. His extremities were cool to the touch without evidence of mottling.

The critical care team packaged and loaded the patient into the helicopter, and they completed the primary survey. The patient remained sedated. The patient had a second intravenous catheter placed in the right antecubital fossa. A crystalloid fluid bolus was initiated with 0.9% normal saline at 20 mL/kg. Continuing with the circulation assessment, it was noted that the patient had an open tibia and fibula fracture on the left. His thigh on the right appeared to be edematous with deformity. His pelvis felt stable with palpation. The GCS was a 3T because the patient was intubated, sedated, and paralyzed. During flight, the patient was wrapped in blankets to prevent hypothermia. Intravenous fluids were continued. A level I trauma alert was sent to the receiving tertiary trauma center.

Upon arrival to the receiving facility, the trauma team was at the bedside. The ATLS primary survey was initiated. The endotracheal tube was confirmed by bilateral lung sounds, fogging of the tube, equal rise and fall of the chest, and an $ETCO_2$ measurement of 41 mm Hg. Breath sounds were markedly diminished on the right. There was no evidence of jugular venous distention or displaced trachea. The trauma team activated the massive transfusion protocol because the patient had a blood pressure of 74/38 and a heart rate of 115, oxygen saturations of 93%, and a body temperature of 95.3°F. Secondary to the blast-related injuries, they anticipated internal hemorrhage. A second bolus of 20 mL/kg normal saline was given while waiting upon the arrival of blood products. The patient's GCS remained 3T. The patient was rolled, and his back was evaluated. There were considerable contusions over his back with a predominance near the lumbar spine. The patient was again covered with warm blankets within the heated trauma room in order to prevent hypothermia. Ketamine was administered in intravenous boluses for continued sedation.

The adjuncts to the primary survey were completed. The patient had a chest

1067-991X/$36.00

http://dx.doi.org/10.1016/j.amj.2017.05.007

Figure 1. The initial chest radiograph showing hyperinflation of the right lung.

radiograph that revealed complete opacification of the left lung. The right lung was hyperinflated with herniation to the left (Fig. 1). A pneumothorax and hemothorax could not be excluded.

The endotracheal tube tip was located in the right main stem bronchus. The trauma team pulled the endotracheal tube back 2 cm. A second chest radiograph was ordered and revealed the endotracheal tube to be above the carina. The pelvis radiograph revealed no evidence of fracture. Focused assessment with sonography for trauma examination was completed. Free fluid was visualized in the abdomen. At this time, the ventilator started to alarm. Because of the suspicion of a pneumothorax, a needle decompression was performed in the second intercostal space in the midclavicular line with an 18-G needle on the right side. A large rush of air was noted. The team prepared for chest tube placement in the right fourth intercostal space in the midaxillary line. A secondary survey was completed, and appropriate radiographs were ordered for the left lower leg and the right femur. Fractures were confirmed in both anatomic regions. The femur fracture was noted to be closed, whereas the lower extremity fracture was open (Fig. 2).

The patient had a computed tomographic (CT) scan completed of his head, chest/abdomen/pelvis, and entire spine. The CT images of the head and thoracic and cervical spine were essentially normal. The CT image of the chest/abdomen/pelvis revealed a large right pneumothorax with a shift of the mediastinum to the left. The chest tube was in place. There were bilateral pulmonary contusions. Additionally, in the abdomen, there were areas of low density consistent with a splenic injury. There was also concern for adrenal hemorrhage. A pneumoperitoneum was also documented. It was believed that this could represent a bowel injury. The CT spine of the lumbar spine revealed fractures involving the body of L4 and L5 vertebrae with retropulsion of the posterior cortex of L4 vertebra (Fig. 3A and B).

The pediatric intensivist and surgeons from the trauma, orthopedic, and neurosurgery services were present for a discussion on the plan of care. The patient was taken emergently to the operating room for open reduction and internal fixation of his right femur. He also had an irrigation and debridement of the open left lower leg wound. Closed reduction of the tibia and fibula on the left was performed. Surgical closure of the laceration overlying the fracture was also completed once the irrigation had been completed. The patient was admitted to the pediatric intensive care unit (PICU) without incident.

This patient was admitted to the PICU after his orthopedic surgeries. Once he was admitted to the PICU, he was sedated with a propofol drip. The ventilator settings were changed to pressure-regulated volume control/synchronized intermittent mechanical ventilation with a pressure support of 10, a rate of 18, a positive end-expiratory pressure of 8, and a fraction of inspired oxygen of 30%. His arterial blood gas continued to improve, and he was weaned off the ventilator on day 8.

He did require neurosurgical evaluation for his L4 burst fracture. He had a posterior lateral lumbar fusion with pedicle screw instrumentation to reduce the burst fracture. He had a second orthopedic surgery to remove external hardware from his right femur. He was hospitalized for a total of 19 days and was discharged to rehabilitation. After his stay in the inpatient rehabilitation unit, he was discharged in stable condition and had follow-up with neurosurgery and orthopedics as an outpatient.

Discussion

Blast injuries are broken into 5 categories: primary, secondary, tertiary, quaternary, and quinary.[1-4] Primary blast injury (PBI) results from the direct effects of the blast wave on the tissue. Air is more easily compressible than water, and inertia occurs at the boundaries of tissues of different densities. The blast wave causes an irreversible effect related to the differences in tissue tensile strength and speed of the blast wave through the different tissue densities. Spalling occurs at the interface of tissues when vibrations pass through different tissue densities causing layers of tissue to separate.[2] The onset of damage occurs when the blast wave compresses the tissues, and the resulting forces exceed the strength of the tissue causing shearing.[5,6] Tissues of lower density are accelerated faster than adjacent tissues of higher density. Shearing of tissue boundaries can cause traumatic amputations and avulsions. The most common primary blast injury affects gas-containing organs. The middle ear, lungs, and bowel are the most commonly affected, with pulmonary barotrauma being the most common fatal injury.[7] Implosion results from the rapid compression and subsequent explosive expansion of gasses as the high pressure wave propagates over hollow or fluid-filled spaces. Gases that dissolve are forced out of solution by the high pressure creating air emboli. The rapid expansion of compressed gasses is so explosive that it causes barotrauma by rupturing capillaries and forcing air into adjacent tissues. Although these injuries may appear impressive, it is also important to understand that injuries sustained by a PBI may be solely internal, with no external component.[2]

Secondary blast injuries are caused by accelerated debris from the blast. These