J Forensic Sci, January 2006, Vol. 51, No. 1
doi:10.1111/j.1556-4029.2005.00027.x
Available online at: www.blackwell-synergy.com

CASE REPORT

John Plunkett,[1,2] *M.D.*

Resuscitation Injuries Complicating the Interpretation of Premortem Trauma and Natural Disease in Children

ABSTRACT: Minor soft tissues injuries are common in both adults and children who have had cardiopulmonary resuscitation (CPR). Potentially life-threatening injuries are rare. The pre-arrest history in a resuscitated adult often assists the pathologist to interpret autopsy findings. In contrast, an infant or child may not have a reliable history. In this situation, it may be difficult if not impossible to distinguish resuscitation injuries from pre-existing accidental or inflicted trauma. I describe two children who had significant autopsy-documented injuries initially attributed to abuse. The State filed murder charges against the caretaker in each case. However, further history and review of the medical records suggested that resuscitation rather than pre-arrest trauma caused almost all of the injuries. The State dismissed the charges in the first case. A jury returned a "not guilty" verdict in the second. It is essential to consider the entire history and not just autopsy findings when performing a death investigation.

KEYWORDS: forensic science, artifact, child abuse, resuscitation

Resuscitation frequently causes skin, soft tissue, and skeletal injuries in children and adults. Iatrogenic injuries include contusions and puncture wounds from IV placement (1), burns from defibrillation, and rib and sternal fractures (in adults) (2). However, lip contusions, lacerations and tooth fractures from attempted intubation, facial contusions from air-bag valve-mask use (1,3), and extensive subcutaneous hematomas from attempted jugular or subclavian catheter placement may be more difficult to interpret, especially if the resuscitation history is unknown or not sought. Published life-threatening infant resuscitation injuries include right atrial rupture (4); trachea perforation and gastric rupture (5); hepatic, splenic, and pancreatic lacerations (6); and retroperitoneal hemorrhage (7). The incidence of these complications is not known. Krischer et al. (8), in a comprehensive prospective study of 705 autopsied deaths in which cardiac resuscitation had been performed, documented liver and spleen lacerations in a 10-month-old child, and gastric rupture in a 16-month-old child. However, this study does not state the age range or distribution of the subjects, or tabulate specific injuries to a specific age.

This report describes two children with significant injuries most likely caused by resuscitation. In each case, the injuries were initially interpreted to represent pre-arrest trauma, resulting in capital murder charges against the caretaker who was with the child at the time of the collapse at home.

Case #1

A 6-year-old male with no significant past medical history (according to the Medical Examiner's initial investigation) lived with his biologic mother and his mother's boyfriend. The boyfriend had lived with the mother and child since the child was a baby. There was no Child Protection involvement with the family; the mother and boyfriend's had a stable and nonviolent relationship; and the child's mother and other friends reported that he had a good relationship with the child. The boyfriend stated that he had been alone with the child since approximately noon and that he had last seen him alive at 12:30 pm. The child had been complaining of abdominal pain and was "sleepy," but otherwise appeared and acted normally. He found the youngster collapsed and not breathing on the bedroom floor at 1 pm, and called rescue personnel. The "911" operator instructed him in cardiopulmonary resuscitation (CPR), and he initiated and continued chest compression until paramedics arrived 11 min after the call. The child was in a complete cardiopulmonary arrest (asystole) and early rigor, but the resuscitation attempt was continued enroute to a local hospital. He was dead on arrival in the emergency room (ER), and the ER personnel discontinued the resuscitation.

A postmortem examination indicated no cutaneous injuries. However, there was a 2.5 cm laceration of the liver at the attachment of the ligamentum teres; a 2.0 cm laceration of the right adrenal gland adjacent to and beneath the hepatic laceration; and an estimated 300 mL of intra-abdominal blood. Microscopic examination indicated that the hemoperitoneum was "acute" and had no evidence for an inflammatory infiltrate. The autopsy report stated that the other internal organs were grossly and microscopically normal. The pathologist told the Prosecutor that the condition of the child when he was first examined by emergency medical services (EMS) personnel (rigor with asystole) was inconsistent with the history of a maximum 30 min postmortem interval given by the boyfriend, that the death was caused by the hemoperitoneum due to hepatic and adrenal lacerations, and that it was a homicide. The State filed first-degree murder charges against the boyfriend.

[1] Departments of Pathology and Medical Education, Regina Medical Center, Hastings, MN.

[2] Present address: 13013 Welch Trail, Welch, MN 55089.

Received 30 Jan. 2005 ; and in revised form 5 June 2005; accepted 9 July 2005; published 26 Dec. 2005

Outcome

Two pathologists and a pediatric pulmonologist independently reviewed the death investigation and autopsy at the request of the defense attorney. Review of the child's medical records indicated that he had unstable asthma for which his physician had prescribed albuterol sulfate syrup. Examination of the autopsy lung slides showed striking emphysematous changes (Fig. 1). Mucous plugs occluded all of the large and small bronchi and bronchioles, and there was mucous gland hyperplasia and thickening of the bronchiolar muscle walls (Figs. 2–3). An independent witness, a workman in the apartment complex, stated that he had seen the child alive and apparently okay approximately 20 min before the "911" call. The reviewers discussed their findings with the State's attorney, and the State dismissed the charges.

Case #2

A 21-month-old male lived with his 3.5-year-old brother, his mother, and his mother's boyfriend in an apartment. The children and adults ate dinner at approximately 6 pm, and the children went in their bedroom at 8 pm. The mother stated that she was doing housework, then took a shower 20 ft from the bedroom, and that she heard nothing unusual. The boyfriend stated that the older child came out of the bedroom at 8:15 pm and said his younger brother fell out of bed. (The top of the mattress was 19 in above a carpeted floor.) The boyfriend went into the room and found the child on the floor, groggy but arousable, with blood on the right side of his head. He and the child's mother took the infant by car to a hospital 10 min from their home. He was hypotensive and bradycardic on admission, breathing agonally, and had a rectal temperature of 91.7°F. He was intubated in the ER. A computed tomography (CT) scan indicated a depressed fracture of the petrous portion of the right temporal bone associated with temporal lobe lacerations and a subdural hematoma. The subdural hematoma continued to enlarge. He had a cardiac arrest while being transported to the operating room (OR) approximately 4.5 h after admission. Trained pediatric hospital personnel resuscitated him, but he developed a consumption coagulopathy and arrested four more times over the subsequent 4 h. Resuscitation restored cardiac activity after each arrest, but the child was brain dead. The attending physicians removed the respirator 12.5 h after the initial arrest and 17 h after admission to the hospital.

An autopsy indicated a depressed fracture of the petrous portion of the right temporal bone extending through the right mastoid process to the lambdoid suture. The fracture lacerated the right temporal lobe and caused a right hemisphere subdural hematoma. The child also had abraded contusions of the upper and lower lips (Fig. 4); multiple cutaneous contusions; a fracture of the right tenth rib posteriorly in the mid-scapular line; 100 mL of intra-

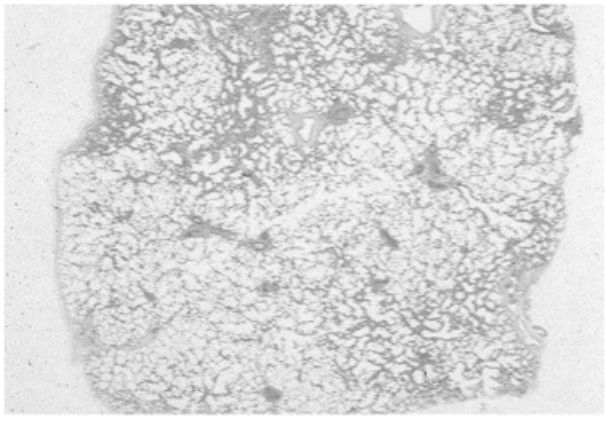

FIG. 1—*Case 1. Lung, whole-mount, hematoxylin and eosin (H&E).*

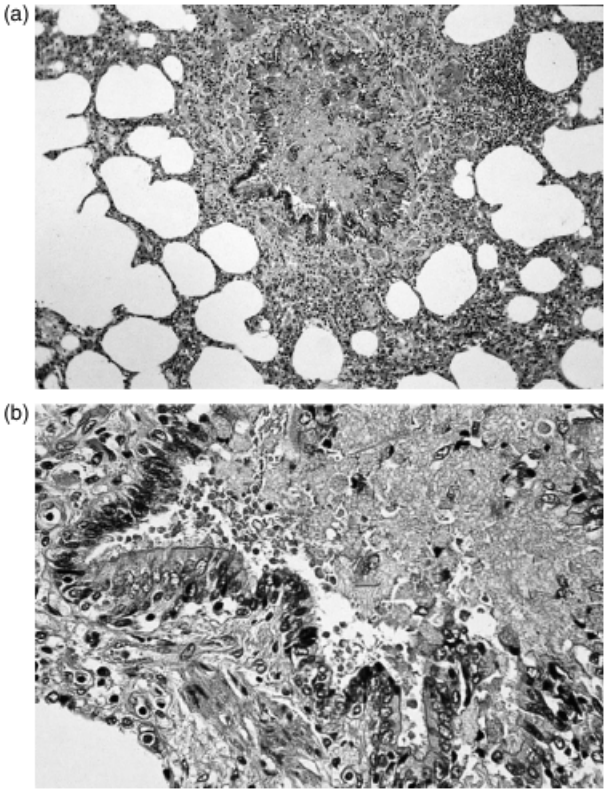

FIG. 2—*(a) Case 1. Lung, hematoxylin and eosin (H&E) × 100. (b) Case 1. Lung, H&E × 400.*

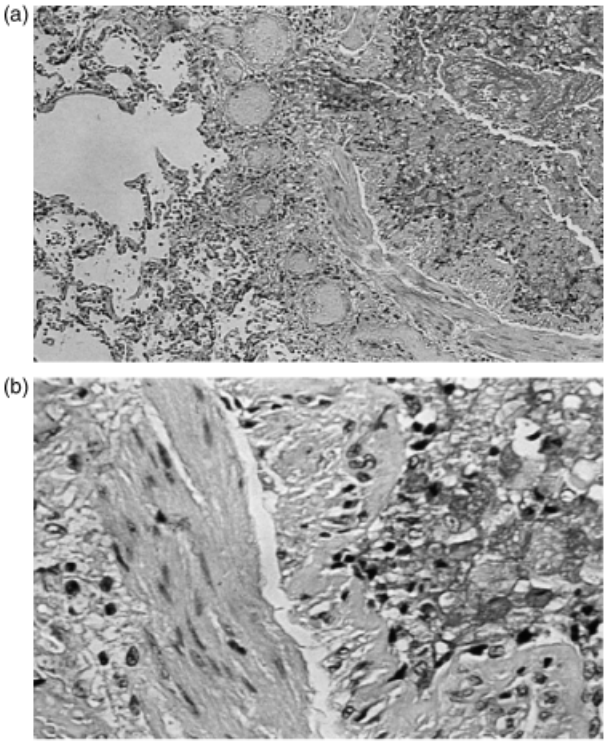

FIG. 3—*(a) Case 1. Lung, mucin × 100. (b) Case 1. Lung, mucin × 400.*

FIG. 4—*Case 2. Upper lip, autopsy.*

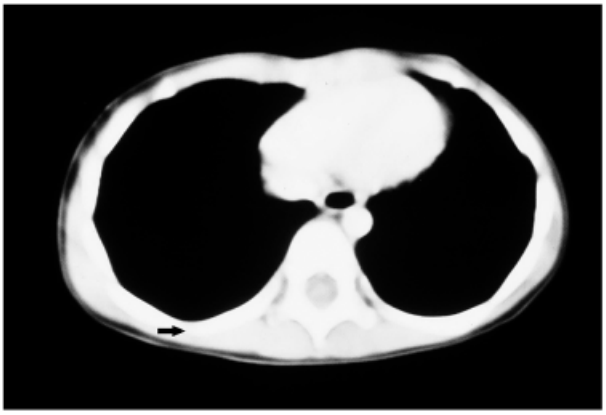

FIG. 6—*Cut 2 through the 10th rib. Arrow indicates the area of fracture found at autopsy.*

peritoneal blood associated with a splenic laceration (Fig. 5); a 300 mL retroperitoneal hemorrhage; edema and ecchymosis of the scrotum; and a healing fracture of the right inferior pubic ramus. The rib fracture had no associated subperiosteal or subpleural blood.

The State indicted the boyfriend for capital murder. The Prosecutor indicated that he would seek the death penalty because of the vulnerability of the victim and the brutality of the attack.

Outcome

The autopsy pathologist concluded that defibrination caused the skin contusions; and that perforation of the right femoral artery during attempted placement of an arterial catheter caused the retroperitoneal hemorrhage and the scrotal ecchymosis and edema. He stated that resuscitation may have caused the lip lacerations and contusions. (The initial ER physician and nursing assessments, independently documented in the Medical Record, indicated that the child's lips and mouth were "normal.") However, he attributed the splenic laceration, the rib fracture, and the intra-abdominal hemorrhage to pre-admission trauma. An abdominal contrast-enhanced CT performed approximately 2.5 h after admission indicated no intra-abdominal or retroperitoneal hemorrhage, normal abdominal organs, and no rib fracture (Figs. 6 and 7). The CT findings suggested that it was possible if not likely that the child's only pre-admission injury was the skull fracture causing a cerebral laceration, for which there was a reasonable nonabuse explanation. The jury deliberated for 4 h and acquitted the defendant.

Discussion

There are a number of factors in *Case #1* that strongly suggest that the liver and spleen lacerations and the intra-abdominal blood were due to the resuscitation, not abuse. It is unlikely that a child with a blood volume of approximately 2000 mL will die acutely from a 300 mL intra-abdominal hemorrhage. The pathologist was not told that the child had a history of asthma and had complained of abdominal pain on the day of his death. The defendant's statement, the "911" tape, and the statement by the workman that he had seen the child alive and well less than half an hour before the paramedics arrived were not available or disclosed to the pathologist until almost 4 months after the autopsy. Further, the macroscopic and microscopic description of the lungs as "normal" was inaccurate. The child had severe acute and chronic asthma. Children with asthma frequently complain of abdominal pain (9–11), and tissue hypoxia forcing peripheral muscle anaerobic glycolysis accelerates rigor, explaining both the child's symptoms and the rapid onset of rigor.

Interpretation of the injuries in *Case #2* is more difficult. The head injury; the healing pelvic fracture; the splenic laceration with intra-abdominal hemorrhage; an acute posterior rib fracture; retroperitoneal hemorrhage; and the abraded contusions of the lips were all consistent with multidirectional force injury. However, the autopsy findings were inconsistent with the known social history of the defendant (no domestic violence and an excellent relationship with both children), and the history as reported by the mother. The older child, who was in the bedroom with his brother,

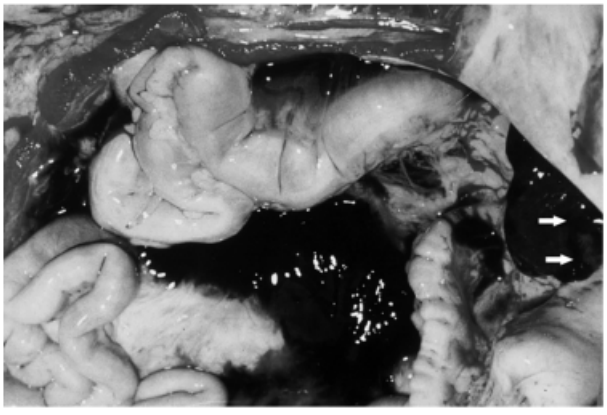

FIG. 5—*Splenic laceration (arrows) and hemoperitoneum.*

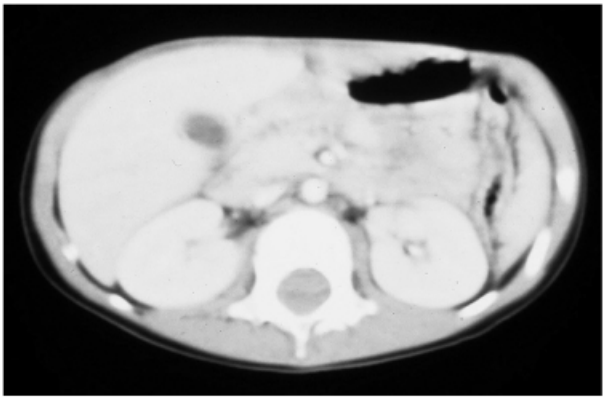

FIG. 7—*Computed tomography cut 10.*

gave several inconsistent and contradictory accounts to Law Enforcement of what happened. These included that "he choked," that his mother dropped him, and that "he fell and blood was coming from his nose and ears and mom put a bandaid on his ear and he vomited."

The mother's statement to Law Enforcement, translated and transcribed by an interpreter, was not available to the defense attorney until shortly before the trial, 3 years after the death. In this statement, she said that the older child initially told her that the younger child had been jumping up-and-down on the bed, then fell to the floor. The defense attorney asked me what would happen if the younger child was laying on the floor and his older brother, who weighed 45 lb, jumped off the bed, landing on the side of his head. Biomechanical reconstruction using a variety of scenarios indicated that this possibility was reasonable and consistent with the observed injury. No one ever asked the sibling if this is what happened, and I did not consider it until I reviewed the mother's statement several years after the death.

Incision of the femoral artery during catheter placement caused the retroperitoneal hemorrhage, and the scrotal edema and hemorrhage. Hospital personnel described that the skin contusions, accentuated by defibrination, developed with the slightest pressure during the closed-chest CPR. Placement of an orotracheal tube caused the lip contusions and abrasions: The initial ER nursing and physician assessments independently and clearly state that the child's lip, mouth, and buccal mucosa were normal. The cause of the remote pubic ramus fracture is not known. He had a witnessed fall down a flight of stairs at his grandparents' home approximately 2 weeks before his death, and an earlier unwitnessed fall at a playground. One radiologist who reviewed the radiographs stated that the fracture had occurred at least 2 weeks prior to the death; a second said that the fracture occurred at least 4 weeks earlier. He never showed any signs or symptoms of a groin injury, and the fracture did not affect his ambulation. The chest radiograph performed in the hospital did not show the rib fracture. However, the diaphragm partially obscured the rib, and plain films are insensitive to acute nondisplaced rib fractures. The contrast-enhanced abdominal CT performed 2.5 h after admission to the hospital (3 h after the head injury) indicated no intra-abdominal bleeding, parenchymal lacerations, or rib fractures. Although the sensitivity of an abdominal CT for intra-abdominal blood is not 100% (12–15), this scan's excellent technical quality and the extended time between hospital admission and the scan strongly suggest that the rib fracture, splenic laceration and hemoperitoneum occurred after it was performed. It was likely, based on all of the above considerations, that a single unidirectional force caused the head injury, allowing a reasonable nonabuse explanation to be considered.

Conclusion

Resuscitation injuries may be consistent with "a" cause of death independent of other pre-arrest trauma or natural disease. The untrained caretaker likely caused the hepatic and splenic lacerations in *Case #1*. Skilled hospital personnel likely caused the injuries other than the head and groin injuries in *Case #2*. Any of the injuries in *Case #2* (lip lacerations; cutaneous contusions; rib fracture; retroperitoneal hemorrhage; and splenic laceration with intra-abdominal hemorrhage), if isolated, would have had a high likelihood of correct interpretation, especially if the medical record was examined and the hospital/prehospital personnel were interviewed. However, if the injuries in *Case #2* are considered in total, it would be difficult to conclude that this was not a battered child and that the death was not due to abuse, especially with the background of a severe unexplained head injury. Excellent written and photographic autopsy documentation; correlation of the autopsy findings with the medical record by the autopsy pathologist in *Case #2*; verifiable social histories; and detailed medical and prehospital records made it possible to consider alternative explanations.

Resuscitation is an uncommon if not rare cause for significant injury in a child. Most cases that appear to be abuse are abuse. However, some are not. The only way to differentiate between the alternative conclusions is to consider the unique characteristics for each case. If there is new information, the conclusion must be re-evaluated. To do otherwise is an injustice and may cause great harm.

Acknowledgments

To Michael Arnall, M.D., who assisted with *Case #1*; to Randy Berman, J.D., Peggy Natale, J.D., and Scott H. Cupp, J.D., for the courage to pursue truth rather than resolution; and to John E. Smialek, M.D., who assisted with *Case #2*, and whose life was too short. Conflicts: none. Sources of support: none.

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Additional information and reprint requests:
John Plunkett, M.D.
13013 Welch Trail
Welch, MN 55089
E-mail: plunkettj@frontiernet.net