G70 Fatal Pediatric Head Impact Biomechanics: Homicide vs. Accident

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After attending this presentation, attendees will develop skill in determining the head impact accident scenario and injury mechanisms responsible for fatal pediatric head injuries. In addition, attendees will develop skill in determining injury causation in possible homicide cases involving complex, interdisciplinary medical and biomechanical engineering concerns.

When handling death cases where issues involving occupant dynamics and impact injury biiomechanics have to be addressed, medical examiners should increasingly feel more comfortable seeking input and support from skilled biomechanical engineering colleagues.

A 14-month-old male in good health sustained a severe closed head injury at a babysitter's house, and he died in the hospital few hours later. Head CT Scan performed prior to his death demonstrated a large occipital fracture, diffuse cerebral edema and tentorial subarachnoid hemorrhage with no midline shift. An autopsy was performed 27 hours post death. Autopsy findings are provided below, prior to addressing accident witness statements and reconstruction of the accident versus homocide scenario responsible for the death of this child.

Autopsy findings Summary:

1. Blunt Force Craniocerebral Injury:
   a. No lacerations, abrasions or contusions seen on skin of posterior scalp.
   b. A 15 x 11 cm area of subscapular and periosteal blood extravasation in occipital and posterior parietal regions.
   c. Extensive displaced fractures of occipital bones extending into the posterior aspect of both parietal bones.
   d. Film of epidural blood extravasation over skull fractures.
   e. An estimated 10 ml of liquid and partially clotted subdural blood extravasation, predominately over vertices of cerebral hemispheres, but also over base of skull.
   f. Moderate diffuse subarachnoid blood extravasation over entire brain with increased concentrations in left para sagittal/sagittal cortex and left temporal lobe.
   g. Apparent tear of falx cerebri anteriorly.
   h. A 2 x 1.5 cm contusion, right cerebellar hemisphere. i A 1 cm contusion, right parieto-occipital lobe.
   j. Blood extravasation surrounding each optic nerve.
   k. Retinal blood extravasation.
   l. Blood extravasation on the left nerve roots of C1 and C2 vertebrae.
   m. Subdural spinal cord blood extravasation.
2. Evidence of hypoxic-ischemic encephalopathy:
   a. Diffuse gyral flattening and sulcal narrowing.
   b. Cerebral tonsillar herniation.
   c. Cerebral edema and early neuronal degeneration on histology.
3. Small, scattered, circular areas of erythema with central dried punctures resembling insect bites on skin.

Witness Statement:

The babysitter, the only adult witness to this accident, provided accident scenario descriptions (a) during the 911 call post-accident, (b) to the EMS crew, (c) to the emergency room and hospital personnel, and (d) to investigating police officers; all of the accident scenario statements provided by the babysitter remained consistent. Namely, the 14month-old boy was standing at rest, having just picked up a popular toy from a toy box, and he was facing two older children who were playing across the room. Suddenly, these two older children ran together fast towards the 14-month-old boy. As these two older boys approached this 14-month-old boy, still running fast, these older boys became entangled and they tripped and fell toward the 14-month-old boy. The 14-monthold boy was, in effect, gang-tackled by the two older boys, causing the 14-month-old boy to rotate backwards at a high rate of speed, pivoting about his feet, resulting in the back of his head violently impacting the bare, hardwood floor.

Impact Injury Biomechanics:

1. Analysis of all of the injuries sustained, and of the possible injury mechanisms responsible for each injury, led to the conclusion that one, single, violent, blunt blow, sustained by the back of the head of the 14-month-old boy, induced all of the injuries sustained. This injury biomechanics analysis included study of the pattern and extent of the skull fractures sustained and consideration of how this depressed skull fracture resulted in an increase in intracranial pressure sufficient to have induced hemorrhages in the region of the

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optic nerves and retinae.

2. Dynamic and impact biomechanic analyses were then performed to study (a) the kinematic consequences of collisions of the two older boys into the 14-month-old boy, along with (b) the magnitudes of the collision-induced increases in head-to-floor slam down velocities.

These engineering analyses demonstrated that the collision of the two older boys into the 14-month-old boy standing at rest could have increased the 14-month-old boy's head-to-floor slam down velocity to a level more than capable of producing the severe skull fractures and fatal brain injuries sustained. In addition, these analyses demonstrated how unlikely it would have been for simple fall, starting at rest from a standing height and not involving a collision, to have caused these catastrophic head injuries.

Recommendations:

In an interdisciplinary case such as this one, whether or not the death of this 14-month child was caused by homicide would be difficult for most medical examiners to judge absent feedback and support from a team member skilled in biomechanical engineering. When the quest for accurately determining injury causation involves consideration of complex medical and biomechanical engineering issues, forensic pathologists should seek support from skilled biomechanical engineering colleagues.

Head Impact Injury Biomehchanics, Skull Fracture Mechanics, Occupant Kinematics

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