H7 Modeling of Inflicted Head Injury by Shaking Trauma in Children—What Can We Learn? Part 1: A Systematic Review of Animal Models

Marloes E.M. Vester, MD, Netherlands Forensic Institute, The Hague, ZH 2497GB, NETHERLANDS; Rob A.C. Bilo, MD, Netherlands Forensic Institute, The Hague 2490 AA, NETHERLANDS; Arjo J. Loeve, PhD, Delft University of Technology, Delft, Zuid-Holland 2628 CD, NETHERLANDS; Rick R. Van Rijn, PhD, Amsterdam UMC, Amsterdam 3544MT, NETHERLANDS; Jan Peter van Zandwijk, PhD, Netherlands Forensic Institute, The Hague, Zuid Holland 2497 GB, NETHERLANDS*

Learning Overview: After attending this presentation, attendees will understand the different forces and their respective injuries in animal studies with lambs and piglets mimicking inflicted head injury without any direct external impact.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by offering a systematic review to address the pathophysiology in order to discuss the forces needed to cause injury in infant animals. These values are important in the interpretation of injury in alleged human abusive head trauma cases.

Injury in infants caused by repetitive acceleration-deceleration trauma (e.g., caused by shaking) in the absence of a direct impact trauma to the outside of the head, other than chin-chest and head-back collisions, is a process better defined as Inflicted Head Injury caused by Shaking Trauma (IHI-ST). IHI-ST, also commonly referred to as Abusive Head Trauma (AHT), can cause brain injury. Yet, the exact pathophysiologic mechanism and its associated thresholds remain unclear. In this systematic review, an overview of animal model studies for shaking injury and their findings on tissue damage will be provided.

A systematic review was performed in MEDLINE® and Scopus® for articles on the simulation of inflicted head injury in animals, up to January 1, 2017. After collection, the studies were independently screened by two researchers for title, abstract, and finally full text, and on methodological quality.

After de-duplicating of the search results, 1,977 articles remained, resulting in 23 articles eligible for full text screening. A total of 12 articles were included after full text screening. Three articles were based on a single study population of 13 lambs, all of one research group. The other 9 articles were separate studies performed in piglets, all by a single second research group.

The 5-to-10-day-old, anesthetized lambs were vigorously shaken by adult humans, resembling human infant shaking, and euthanized after six hours. Overall, the shaken lambs showed injuries of the brain, spinal cord, and eyes. The control animals did not show any relevant abnormalities. Injury was more common and more extensive in the lower weight, younger lambs, who all died prematurely.

In five studies, 3-to-5-day-old piglets received a rapid inertial, non-impact head acceleration in the transverse (axial) plane, while three other articles used accelerations in different planes (transverse, sagittal, or coronal). Lastly, one article reported solely on transverse accelerations as well, yet in 4-week-old piglets. In piglets, it was found that rotation direction was of influence on the neurological and histology results. Tissue strain might be of influence on the injuries found in piglets and lambs. However, the anatomical differences between animals and humans, along with the inconsistent choice of (mostly non-cyclic) rotation directions in the various studies make an adequate comparison between studies and between animals and humans very difficult.

The lamb articles give some information on tissue damage after inflicted head injury. The piglet studies only provide information on consequences of a single plane rotational movement. Generally, with increasing age and weight, there was a decrease of axonal injury and death. Future studies should focus on every single step in the process of a free head movement in all directions, resembling human IHI-SC. In part II of this systematic review, biomechanical models will be evaluated.

Closed Head Injuries, Child Abuse, Animal Models