

## “Shaken baby syndrome” and forensic pathology

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The concept of shaking baby syndrome (SBS) and the “triad” of encephalopathy, subdural hemorrhage (SDH), and retinal hemorrhage (RH) have become, as Dr. Byard [1] states, a hotly debated topic. SBS has come under increased scrutiny as our understanding of the mechanisms underlying the physiologic responses of neonates and infants continues to evolve.

The triad can be secondary to trauma, but many forensic pathologists consider that impact is necessary to account for the signs and symptoms; as a consequence, the term SBS has been replaced by “shaken impact” syndrome or the more nondescript “abusive head trauma.” The issue is not whether or not shaking is injurious; Finnie’s experiment [2] clearly shows that smaller animals can die from repeated shaking. Instead, the issue is whether shaking alone can generate the forces associated with bridging vein rupture and SDH described in experimental models of SDH [3].

It is now well established that bridging vein rupture is not the only source of SDH in infants [4–6]. RHs also have multifactorial etiology [7, 8]. The small intradural vessels of the parasagittal dura, the falx, and tentorium are more extensive in young babies, and these vessels can leak to produce intradural and subdural hemorrhage. The extensive valveless plexus within the intracranial dura connects with the venous plexus of the spine and together form the craniospinal venous system [9]; the function of this system is not fully understood, though

it is known to be involved in the maintenance of intracranial pressure, and affected by posture and respiration.

This brings us to the possible role of hypoxia in SDH. While hypoxia on its own is not enough to produce SDH, there is a strong association between hypoxia and SDH [5, 6]. Additional factors such as increased venous pressure or coagulation disorders may serve to extend an intradural hemorrhage (IDH) into a thin-film SDH over the hemispheres and along the dural folds.

Pathologists who do large numbers of perinatal autopsies see the close association between hypoxia and IDH/SDH [10]. Critics who sustain that the trauma of delivery has not been accounted for ignore the fact that with current obstetric care, traumatic tears of the falx or tentorium are extraordinarily rare [5]. In fact the “trauma” of delivery is one of hypoxia and increased intracranial pressures and not one of traumatic acceleration/deceleration.

Geddes et al. [11] were the first to report that the microscopic changes seen in the brain of infants who died of inflicted head injury were hypoxic-ischemic rather than traumatic. The lack of traumatic changes in the brain made them suggest an alternative pathway for the findings of SDH and RH [12]. Since then other authors have postulated neck injury as the event that precipitates apnea and results in hypoxic changes of the brain [13].

Most of the current literature lumps together children under 2–3 years of age; however, the anatomy of the dura of infants below the age of 6 months is very different from an infant of age 2. Age-dependent changes in the cardiovascular, respiratory, immune, and coagulation systems, as well as individual variation in maturation, need to be considered when evaluating the triad in infants.

We agree that ascribing intention to a combination of symptoms is absurd. While lethal craniocerebral trauma seems appropriate [1], this does not include the children

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that do not die. Therefore, a more appropriate term would be the one coined by Dr. Guthkelch (who originally described SBS) of “retino-dural hemorrhage of infancy” [14]. Finally, we urge further study of the unique anatomy and physiology of the infant dura. As Andeweg [15] so appropriately states, “In the natural sciences, truth is ultimately determined by the structure and mechanisms of nature; they are not affected by dictum, vote, tradition, or fashion.”

## References

1. Byard RW. “Shaken baby syndrome” and Forensic pathology: an uneasy interface. *Forensic Sci Med Pathol*. doi:[10.1007/s12024-013-9514-7](https://doi.org/10.1007/s12024-013-9514-7).
2. Finnie JW, Blumberg PC, et al. Neuropathological changes in a lamb model of non-accidental head injury (the shaken baby syndrome). *J Clin Neurosci*. 2012;19(8):1159–64.
3. Gennarelli TA, Thibault LE. Biomechanics of acute subdural hematoma. *J Trauma*. 1982;22(8):680–6.
4. Mack J, Squier W, Eastman JT. Anatomy and development of the meninges: implications for subdural collections and CSF circulation. *Pediatr Radiol*. 2009;39:200–10.
5. Cohen MC, Scheimberg I. Evidence of occurrence of intradural and subdural hemorrhage in the perinatal and neonatal period in the context of hypoxic ischemic encephalopathy: an observational study from two referral institutions in the United Kingdom. *Pediatr Dev Pathol*. 2009;12:169–76.
6. Scheimberg I, Cohen MC, et al. Non-traumatic intradural and subdural hemorrhage and hypoxic ischaemic encephalopathy in fetuses, infants and children up to 3 years of age. Analysis of two audits of 636 cases from two referral centers in the UK. *Pediatr Dev Pathol*. 2013;16:149–59.
7. Muller PJ, Deck JHN. Intraocular and optic nerve sheath hemorrhage in cases of sudden intracranial hypertension. *J Neurosurg*. 1974;41:160–6.
8. Aryan HE, Ghosheh FR, et al. Retinal hemorrhage and pediatric brain injury: etiology and review of the literature. *J Clin Neurosci*. 2005;12:624–31.
9. Pearce JM. The craniospinal venous system. *Eur Neurol*. 2006;56:136–8.
10. Cohen M, Cox P, et al. Lack of evidence for a causal relationship between hypoxic ischemic encephalopathy and subdural hemorrhage in fetal life, infancy and early childhood. A response. *Pediatr Dev Pathol*. 2007;10:500–1.
11. Geddes JF, Vowles GH, et al. Neuropathology of inflicted head injury in children: II. Microscopic brain injury in infants. *Brain*. 2001;124:1299–306.
12. Geddes JF, Tasker RC, et al. Dural hemorrhage in nontraumatic infant deaths: does it explain the bleeding in “shaken baby syndrome”? *Neuropathol Appl Neurobiol*. 2003;29:14–22.
13. Matshes EW, Evans RM, et al. Shaken infants die of neck trauma, not of brain trauma. *Acad For Pathol*. 2011;1:82–91.
14. Guthkelch AN. Problems of infant retino-dural haemorrhage with minimal external injury. In: *Houston Journal of Health Law & Policy*. Houston: University of Houston Health Law and Policy Institute; 2012.
15. Andeweg J. The anatomy of collateral venous flow from the brain and its value in aetiological interpretation of intracranial pathology. *Neuroradiology*. 1996;38:621–8.