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Law, Child Abuse, and the Retina

There is a longstanding, widespread belief in pediatric medicine that a finding of retinal hemorrhages in an infant or young child is strong evidence of child abuse. This belief originated decades ago as a cornerstone of a now-controversial diagnosis known as Shaken Baby Syndrome (“SBS”) or as Abusive Head Trauma (“AHT”). Decades of medical students have been taught that retinal hemorrhages in an infant or young child mean child abuse until proven otherwise.¹ This dogma has had and continues to have enormous legal implications: expert testimony about retinal hemorrhages is powerful courtroom evidence, which prosecutors and child protection agencies have offered in thousands of criminal and family court cases.

This article urges that the beliefs about retinal hemorrhages are unreliable for legal purposes and, it seems, altogether wrong, yet they are key to the SBS/AHT diagnosis. Most debate in the case law about the forensic reliability of retinal hemorrhages is embedded in a broader discussion about the multifactorial SBS/AHT diagnosis.² This article urges that the beliefs about retinal hemorrhages need to be addressed distinctly and head-on in the courts. Courts should not continue to admit expert testimony about the purported forensic value of retinal hemorrhages.

The Retina

The retina is a thin layer of brain tissue that lines the back of the eye. When light passes through the eye and onto the retina, it triggers electrical and chemical impulses that are transmitted through the optic nerve to the brain, which, in turn, translates such impulses into visual images. Our retinæ work with our optic nerves and our brain to allow us to see.

The retina has several layers, yet is very thin — only about 0.5 millimeter thick. At its widest point, a young child’s retina is about three centimeters across. The retina receives blood primarily from the central retinal artery; after entering the back of the eye, the artery gives off branches that supply blood to capillaries throughout most of the retina. Its counterpart for returning the blood is the central retinal vein, which, too, has several branches that extend across the retina. When any of these retinal vessels bleed outside their structures, they form specks of blood referred to as retinal hemorrhages. Retinal hemorrhages are not visible simply by looking at someone; they need to be sought out via a clinical eye (ophthalmic) examination or via removal and dissection of the eyes at autopsy. As a general rule, with respect to infants, such eye examinations are performed only when SBS/AHT is suspected.

Origins of the Belief That Retinal Hemorrhages Indicate Child Abuse

The discovery of a potential association between retinal hemorrhages and child abuse occurred in the late 1960s. This timing was no accident. Physicians paid little attention to child abuse until the 1960s. This changed

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rapidly after an influential medical article in 1962, which advocated that physicians play a greater role in identifying and reporting abuse.³ This article triggered a surge in medical interest in child abuse, including an exponential increase in medical literature about what physical findings are suspicious for abuse. By the late 1960s, physicians were beginning to report that many abused children had retinal hemorrhages.

The scientific evidence and understandings are nowhere near sufficient to continue permitting experts to testify that retinal hemorrhages are reliable evidence of shaking.

In the early 1970s, an American radiologist and textbook writer named John Caffey, who had been writing about suspicious injuries in children since the 1940s, published three papers urging that shaking is a leading cause of intracranial hemorrhage and brain injury in infants and young children.⁴ Shaking, he urged, even if not violent, could cause intracranial injury to young children and would explain the not uncommon scenario where children reported to hospitals with intracranial hemorrhage (usually in the subdural area around the brain) and neurological dysfunction, yet showed no external signs of impact or other trauma to their heads. Caffey also stated that shaking could explain the retinal hemorrhages often found in abused children, which he speculated were injuries attributable to “traction stresses” within the eye during shaking.

Caffey’s hypothesis that shaking causes subdural and retinal hemorrhages and brain injury eventually became known as the Shaken Baby Syndrome. And it soon became widely accepted in pediatric medicine.

Retinal Hemorrhages Become Nearly Diagnostic of Abuse

By the late 1970s, the hypothesis that retinal hemorrhages can be caused by shaking and other “acceleration-deceleration” forces began to morph into rather categorical medical dogma that such hemorrhages almost always mean child abuse. For example, a 1979 paper reported that “retinal hemorrhage in children under three with or without other evidence of injury is pathognomonic [distinctly characteristic] of the battered child syndrome.”⁵ This view dominated the medical and forensic literature for

decades. A 2001 treatise on SBS advised that the “presence of retinal hemorrhages is virtually diagnostic of the violently shaken infant in the absence of severe accidental trauma.”⁶ A 2002 U.S. Department of Justice guide on child abuse advised: “According to all credible studies in the past several years, retinal hemorrhages in infants are, for all practical purposes, conclusive evidence of shaken baby syndrome in the absence of a

good explanation,” with the only *good explanations* listed as severe auto accidents and falls from several stories onto a hard surface.⁷ Child abuse committees of major medical organizations, such as the American Academy of Ophthalmology and the American Academy of Pediatrics, issued statements endorsing the forensic connection between retinal hemorrhages and child abuse. Pediatric physicians and some forensic pathologists frequently attributed great weight to the presence of retinal hemorrhages when testifying that a child was abused. For example, a 2008 Mississippi case quoted testimony from a prosecution witness that “retinal hemorrhages ... could only be caused by either a massive crush injury to the brain, likened to having a person’s head run over by a car, or by Shaken Baby Syndrome.”⁸

Questions Emerge

The belief that retinal hemorrhages evidence abuse emerged in the medical literature based on little more than mere speculation. But, over time, the belief came to rest on three primary grounds.

The first was that retinal hemorrhages in young children reflect *traumatic* damage to the retinae that occurs during violent shaking as the vitreous and retina move at different speeds and shear against each other. This hypothesis is known as the vitreo-retinal traction theory. The corollary of the theory is that, when retinal hemorrhages are found, one can assume the child endured severe acceleration-deceleration trauma.

Second, research studies reported a very strong association between retinal hemorrhages and abuse (ranging from 50 percent to 100 percent) and, by contrast, a very low association between such hemorrhages and accidental trauma. Indeed, a leading pediatric ophthalmologist and child abuse specialist reviewed the literature in 1990 and observed: “It is difficult to answer the question whether trauma other than that resulting from deliberate abuse can cause retinal hemorrhage in infants.”⁹ In 2000, he similarly observed: “Most authors find a zero incidence of retinal hemorrhage in accidentally head injured children less than three years of age even in the presence of severe brain injury, subdural and/or epidural hemorrhage.”¹⁰

The third ground was that retinal hemorrhages in child abuse cases occasionally are accompanied by other

Figure 1: A normal eye on cross-section. Major anatomic landmarks are indicated for orientation purposes.

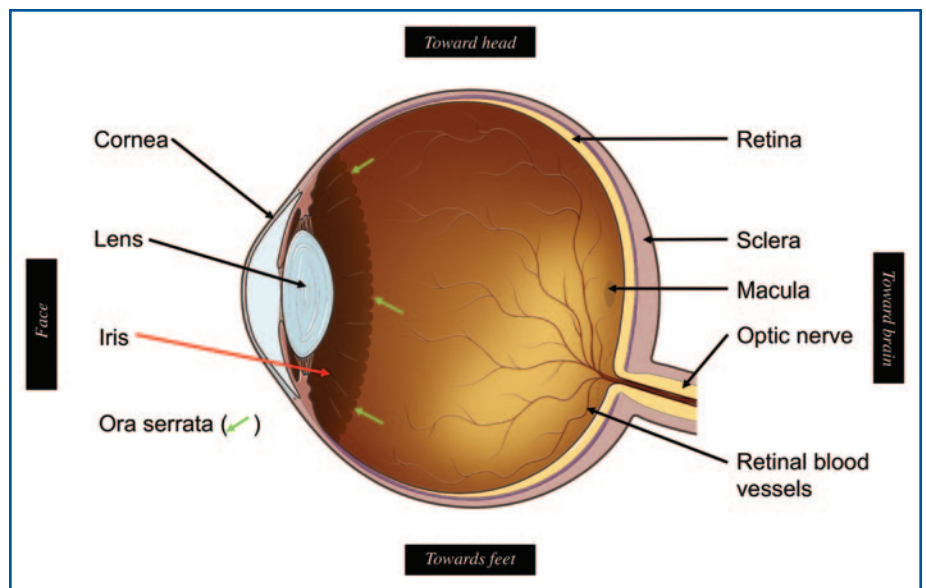
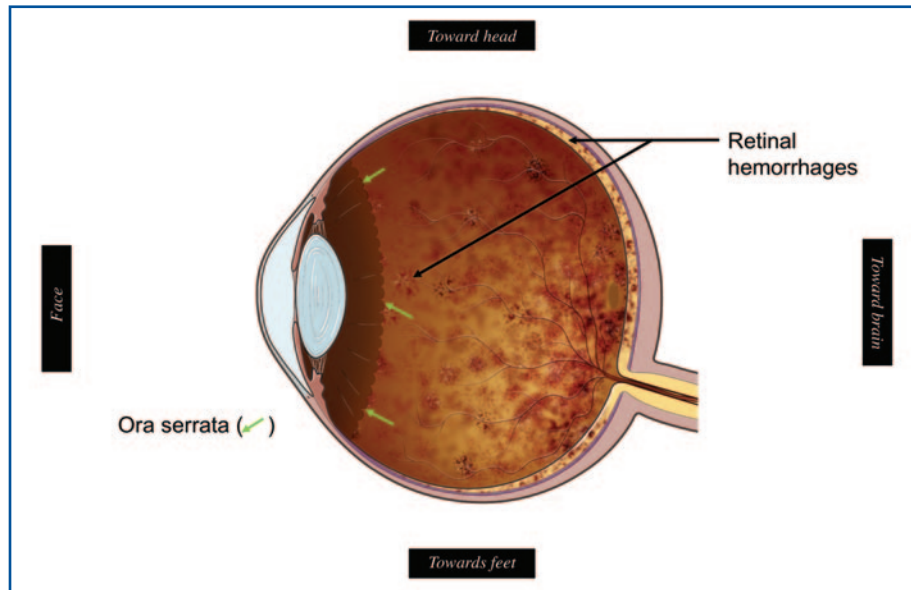


Figure 2: An abnormal eye on cross-section. In this example, retinal hemorrhages are seen within numerous depths (layers) of the retina, as they extend toward the front of the retina (ora serrata) from the back (posterior pole) of the eye. The quantity and distribution of hemorrhages depicted in this eye would be labeled as “severe” retinal hemorrhages by many practitioners.



retinal lesions, such as macular folds and retinoschisis, which, the argument went, supposedly also reflect vitreo-retinal traction and are found only in the context of SBS or accidents akin to a motor vehicle collision.¹¹

That mainstream medicine came to believe that retinal hemorrhages are so specific for trauma in general, and shaking in particular, is astonishing. Before the advent of CT and MR imaging technology in the 1970s, physicians concerned that a patient might have intracranial bleeding or fluid collections — from whatever cause — checked the patient’s eyes for retinal hemorrhages. If retinal hemorrhages were present, so was intracranial bleeding or fluid collections.¹² This clinical understanding — that retinal hemorrhages are a predictable consequence of sudden increases in intracranial pressure that can be associated with intracranial hemorrhage — had been widely accepted since the early 1900s.¹³ A 1957 paper experimentally confirmed the understanding by inducing retinal hemorrhages in primates by increasing intracranial pressure.¹⁴ Yet, the pediatric physicians advocating the forensic significance of retinal hemorrhages overlooked these understandings, deemed them inapplicable to pediatric patients, or dismissed them as unreliable because they preceded the discovery of SBS.

The beliefs about retinal hemorrhages began to falter, however, once the evidentiary foundation for the

beliefs was actually examined, though that did not occur until beginning in the 2000s. The main point of controversy can be described as follows. On one hand is the belief that retinal hemorrhages in these cases reflect vitreo-retinal traction — i.e., mechanical damage to the retina caused by shaking or other severe acceleration-deceleration trauma. On the other hand is the belief that retinal hemorrhages do not reflect mechanical damage to the eye, but that retinal bleeding is, instead, a *secondary* consequence of other pathology or combinations of pathologies, such as raised intracranial pressure, intracranial hemorrhage, fluctuations in blood flow, bleeding or clotting disorders, lack of oxygen (hypoxia), and/or time on life support. The forensic difference between the two approaches is critical: if retinal hemorrhages are a secondary consequence, then they presumably can be found in a variety of traumatic and non-traumatic circumstances not involving shaking or abuse; by contrast, if the hemorrhages reflect mechanical damage to the eye caused by severe acceleration-deceleration forces, then the argument that one may infer abuse from them (in the absence of major accidental trauma) has much greater validity.

For years this debate has played out in the medical and scientific literature. But, at this point, the argument for retinal hemorrhages being merely a secondary finding is now overwhelming. At a mini-

mum, the scientific evidence and understandings are nowhere near sufficient to continue permitting expert testimony in legal cases that retinal hemorrhages are reliable evidence of shaking, acceleration-deceleration trauma, or abuse.

The vitreo-retinal traction theory was adopted without being tested with any methodology or demonstrated experimentally. In recent years, several rounds of animal testing have generally failed to validate the theory that even violent shaking will predictably cause retinal hemorrhaging. For example, a 2017 study shook 50 piglets at levels similar to abusive shaking, yet reported “no ocular injury” in any piglet.¹⁵ By contrast, as noted, medical understanding outside the child abuse context for the last one hundred years is that retinal hemorrhages are a potential consequence of raised intracranial pressure and intracranial hemorrhage and this hypothesis has been repeatedly confirmed. Moreover, if retinal hemorrhages are a distinct and direct physical injury, as opposed to a cascade consequence secondary to other pathology, then one would expect with some regularity to see cases where a child has retinal hemorrhages, but no intracranial hemorrhage or other intracranial or systemic pathologies. But studies have demonstrated that such a picture is almost never seen. Indeed, studies confirm that retinal hemorrhaging is exceedingly rare in children when unaccompanied by intracranial hemorrhaging, brain injury, or a bleeding or clotting disorder.¹⁶ The literature today contains case reports of retinal hemorrhages appearing in a wide variety of traumatic and non-traumatic circumstances ranging from severe infection, several natural diseases, short falls and other household accidents (where intracranial injury occurs), crush injury, coagulopathies, high altitude, aneurysms, and after normal child birth.¹⁷ That such a diverse variety of conditions — both traumatic *and* non-traumatic — can lead to retinal hemorrhages is difficult to square with such hemorrhages being in any way proof of shaking, abuse, or even trauma.

So how to explain the studies that show such strong associations between retinal hemorrhages and abuse? Those studies were methodologically flawed. In particular, they were circular. It was self-fulfilling that they would show a strong association between retinal hemorrhages and abuse. Here is the gist of the problem. The studies that supposedly validated the retinal hemorrhage hypotheses were not undertaken until *after* general acceptance of SBS as a diagnostic syndrome. This meant that the physicians involved in the studies had been trained and apparently

assumed that subdural and retinal hemorrhages in a young child, who had not been involved in major trauma such as a motor vehicle accident, presumptively meant SBS and abuse — and so children with those findings were almost always classified as SBS victims. Conversely, if the child did not have subdural or retinal hemorrhage, or had a history of major trauma akin to an automobile accident, that child would likely be classified as an accident victim or another pathology might be accepted. Predictably, the studies would then report that retinal hemorrhages are very common in abused children, but very rare in accidental trauma, except in instances of major trauma. In sum, because the studies used SBS dogma to determine whether an infant was abused, it was self-fulfilling that they would find a high association between abuse and subdural and retinal hemorrhages, and a low association between accidental trauma and such hemorrhages.¹⁸ From a scientific perspective, the studies are methodologically unreliable; one cannot validate a hypothesis based on a classification system that assumes the association one is purporting to test. Several papers, including a recent multi-year review commissioned by a Swedish governmental agency,¹⁹ have confirmed that the child abuse literature on SBS and retinal hemorrhages is rife with circularity, bias, and other methodological flaws. That the retinal hemorrhage literature relies on circular methodology is an unfortunate fact, not a debatable opinion.

As for the beliefs about the diagnostic specificity of macular folds and retinoschisis, they, too, have been exposed as having been promoted without adequate scientific basis and as likely unfounded. For example, a 2007 study found that the belief that macular folds in infancy are pathognomonic of SBS was based on a total of seven cases spread throughout decades.²⁰ It appears that macular folds and retinoschisis are generally not independent traumatic injuries, but instead merely advanced stages of prolonged retinal hemorrhaging or other internal pathologies such as venous stasis or ischemia.²¹ Indeed, folds and schisis have been shown to develop over time in hospitalized patients and have been observed in cases involving no trauma whatsoever.²²

The Revised Hypothesis

Despite the biomechanical, pathological, and evidentiary shortcomings of the retinal hemorrhage hypotheses, the belief that retinal findings remain strong forensic evidence of child abuse persists,

both in medicine and in courtrooms. This appears to be largely because influential proponents of the hypothesis have offered refinements that, they claim, provide more specific forensic guidance and greater overall reliability.

Under the new formulation, while “mild” and, perhaps, even “moderate” retinal hemorrhages may have multiple potential explanations, “severe” retinal hemorrhages — typically further defined as multilayered, extensive, and/or extending out to the periphery of the retina — are supposedly highly specific for child abuse.²³ This refinement is usually packaged with guidance that trained ophthalmologists, especially those with training in child-abuse related issues, can discern the difference between retinal pathology with an innocent explanation and retinal pathology revealing violence.²⁴

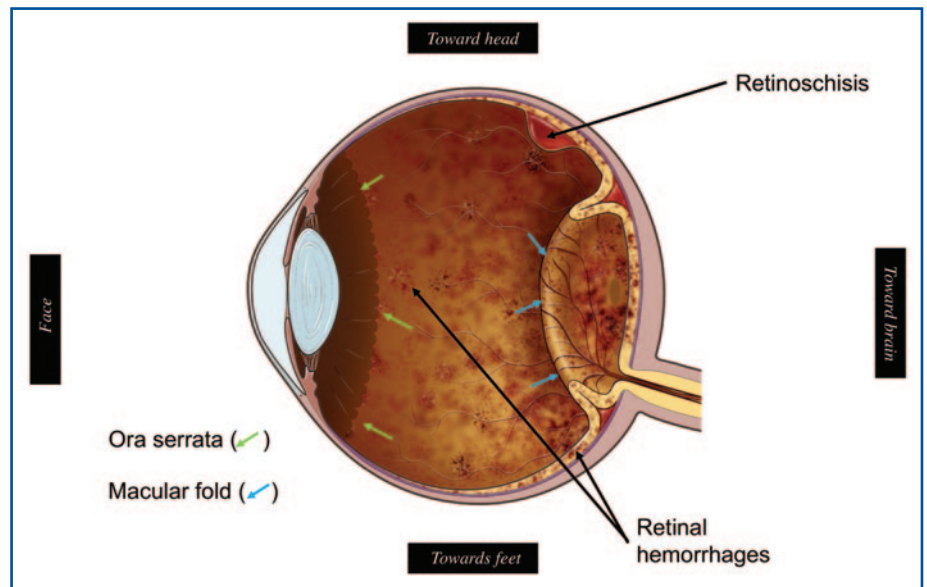
The offered refinement — that severity and expertise can reliably distinguish retinal hemorrhages caused by abuse from retinal hemorrhages resulting from accident or other pathologies including natural diseases — is not an improvement. It is a refinement of an altogether flawed construct, and one that is particularly misleading in that it, without basis, purports to offer even greater forensic certainty.

The range of experimental studies have failed to produce even a single instance of a violently shaken animal

having the type of severe retinal pathology supposedly specific for abuse. The studies supposedly linking severe retinal hemorrhages with abuse contain the same fundamental flaws as the rest of the retinal hemorrhage literature.²⁵ And retinal hemorrhages of all sizes, shapes, location, and severity have been found in accidental trauma and non-traumatic contexts, which is consistent with an explanation that the severity of retinal pathology typically reflects the severity of underlying pathologies and the time they persist rather than anything specific to shaking, abuse, or even trauma. As a 2017 study concluded: “Clinicians should also know that there is no pathognomonic size, distribution, or location of [retinal hemorrhages] seen only in AHT.”²⁶

Notably, when the eyes of consecutive series of patients are examined, without using SBS/AHT dogma to classify the patients as abused or not, the results strongly indicate that it is underlying pathology, not anything unique to shaking, abuse, or trauma that leads to retinal hemorrhages. For example, a 1958 paper reported on eye findings in all young children treated at the Mayo Clinic over an 11-year period with intracranial hemorrhage or fluid collections, of whatever genesis.²⁷ Fifty-one percent of the patients had retinal or subhyaloid hemorrhage, often severe. In 2010, Matshes, a co-author of this article, presented the find-

Figure 3: An abnormal eye on cross-section. In this example, in addition to severe retinal hemorrhages, the retina is physically lifted from the white part of the eye (the cornea), a finding known as “retinal detachment” in adult medicine, but as “retinoschisis” in child abuse parlance, a finding considered by many within the child abuse community to be diagnostic of inflicted injury. An additional finding, a “macular fold”, is also illustrated. The fold — thought to be the result of the physical “pulling” of the vitreous away from the back of the eye during an abusive event — has been reported in a variety of situations, not limited to child abuse.



ings of a retrospective study done at a major metropolitan medical examiner department, which concluded that retinal hemorrhages (even those that were severe) were identified across a range of circumstances, including infants who were abused, who had endured unintentional and intentional blunt head trauma, accidental drownings, and a variety of natural disease states that involved death after a period of critical care hospitalization.²⁸ Lantz and colleagues have examined the eyes of hundreds of patients in a general and forensic autopsy service and report finding retinal hemorrhages, of all appearances and severity, in about 25 percent of both infant and adult cases.²⁹

The notion that ophthalmologists possess special insight to determine whether a child has been shaken or abused is without any scientific basis. Ophthalmologists, of course, know how to do a retinal examination and identify retinal hemorrhages and other lesions. That is why pediatric physicians doing a child abuse examination routinely ask for an ophthalmologic consult — to learn whether the child has retinal hemorrhages, which, again, they believe is strong evidence of abuse. Ophthalmologists, however, have no special expertise in *how* a particular infant or young child sustained retinal hemorrhages, or about the *range* of complex pathophysiological factors that can cause retinal hemorrhages in a young child. In fact, a blinded study of ophthalmologists reviewing RetCam images of retinal hemorrhages in patients with various histories showed major variations among the observers' interpretations, including low agreement even in describing the retinal findings.³⁰

Moreover, retinal examinations are rarely done until well after a child reports to a hospital in a neurologically compromised and often collapsed condition. The child's eyes are thus not examined until many factors are present that are known, individually or in combination, to cause or exacerbate retinal hemorrhaging. Many of these children are near death (or have already died) when their eyes are examined. There is no scientific evidentiary foundation whatsoever to enable anyone to distinguish the extent to which factors such as age, hypoxia, seizures, cardiac arrest, clotting derangement, venous stasis, infection, raised intracranial pressure, intracranial hemorrhage or fluid collections, metabolic collapse, and time on life support have played in contributing to a child's retinal appearance. Claims that

child abuse expertise can provide reliability in an area, where actual science cannot, bear a striking resemblance to now-discredited claims once made by bite mark and arson investigation experts.

Legal Challenges

The dispute about retinal hemorrhages is unlikely to be resolved via consensus any time soon within the scientific and medical communities. Meanwhile, testimony about retinal hemorrhages from prosecution witnesses continues almost unabated.

Increasingly, courts are beginning to recognize the serious admissibility issues concerning testimony about retinal hemorrhages. For example, a recent trial court decision from New Jersey found that the vitreo-retinal traction theory fails to meet even the *Frye* "general acceptance" standard.³¹ For the reasons outlined in this article, given the present understandings and uncertainties, courts performing their gatekeeping duty under *Daubert* and its state law progeny should not permit testimony about the supposed forensic value of retinal hemorrhages.


Conclusion

Only in the rarest of instances, if ever, can retinal findings provide scien-

tifically reliable information relevant to determining whether an infant or young child has sustained inflicted head trauma (whether via shaking, impact, or a combination of the two). Although the beliefs regarding retinal hemorrhages were widely accepted for decades, and still clung to by many pediatric physicians, they lack sufficient reliability for legal purposes. Without question, admission of retinal hemorrhage evidence in the courtroom has led to many miscarriages of justice.

Notes

1. Norman Rosenberg et al., Editor's Comment, *Retinal Hemorrhage*, 10 PEDIATRIC EMERGENCY CARE 303, 303 (1994).
2. See, e.g., *Del Prete v. Thompson*, 10 F. Supp. 3d 907, 930-33 (N.D. Ill. 2014).
3. C. Henry Kempe et al., *The Battered-Child Syndrome*, 181 JAMA 17 (1962).
4. For a discussion of Caffey's papers and their impact, see Randy Papetti, *THE FORENSIC UNRELIABILITY OF THE SHAKEN BABY SYNDROME* § 2.2 (Christopher Milroy ed. 2018).
5. Arthur B. Eisenbrey, *Retinal Hemorrhage in the Battered Child*, 5 CHILD'S BRAIN 40, 42 (1979).
6. Kenneth W. Reichert et al., *Neurologic Sequelae of Shaken Baby Syndrome*, in *THE SHAKEN BABY SYNDROME: A*



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MULTIDISCIPLINARY APPROACH 83 (Stephen Lazoritz et al., eds., 2001).

7. Rob Parrish, U.S. Dep't of Justice, *BATTERED CHILD SYNDROME: INVESTIGATING PHYSICAL ABUSE AND HOMICIDE* 8 (4th printing 2002).

8. *Middleton v. State*, 980 So. 2d 351, 356 (Miss. Ct. App. 2008).

9. Alex V. Levin, *Ocular Manifestations of Child Abuse*, 3 *OPHTHALMOL. CLIN. N. AM.* 249, 256 (1990).

10. Alex V. Levin, *Retinal Haemorrhages and Child Abuse*, in *RECENT ADVANCEMENTS IN PAEDIATRICS* 179 (2000).

11. *Id.* at 175.

12. *See, e.g.*, Kenneth Till, *Subdural Haematoma and Effusion in Infancy*, 3 *BRIT. MED. J.* 400 (1968).

13. *See, e.g.*, Jan E. Leestma, *FORENSIC*

NEUROPATHOLOGY 383 (3d ed. 2014).

14. D. Smith et al., *Pretretinal and Optic Nerve-Sheath Hemorrhage: Pathologic and Experimental Aspects in Subarachnoid Hemorrhage*, 61 *TRANS. AM. ACAD. OPHTHALMOL. OTOLARYNGOL.* 201 (1957).

15. Brittany Coats et al., *Cyclic Head Rotations Produce Modest Brain Injury in Infant Piglets*, 34 *J. NEUROTRAUMA* 235 (2017).

16. *See, e.g.*, Mary V. Greiner et al., *Dedicated Retinal Examination in Children Evaluated for Physical Abuse without Radiologically Identified Traumatic Brain Injury*, 163 *J. PEDIATR.* 527 (2013).

17. *See, e.g.*, Papetti, *supra* note 4, at 130-32 (citing numerous examples from the literature).

18. *See, e.g.*, Papetti, *supra* note 4, § 3.4.4 (discussing the circularity in the SBS/AHT and retinal hemorrhage literature).

19. SWEDISH AGENCY FOR HEALTH TECHNOLOGY ASSESSMENT AND ASSESSMENT OF SOCIAL SERVICES, *Traumatic Shaking: The Role of the Triad in Medical Investigations of Suspected Traumatic Shaking — A Systematic Review* 27-31 (Report 255E) (Oct. 26, 2016).

20. M. Vaughn Emerson et al., *Ocular Autopsy and Histopathologic Features of Child Abuse*, 114 *Ophthalmology* 1384, 1389 (2007).

21. *See id.* at 1388-93.

22. *See, e.g.*, Patrick E. Lantz et al., *Extensive Retinal Hemorrhagic Retinopathy, Perimacular Retinal Fold, Retinoschisis and Retinal Hemorrhage Progression Associated with a Fatal Spontaneous, Non-Traumatic, Intracranial Hemorrhage in an Infant*, 19 *PROC. AM. ACAD. FORENSIC SCI.* 371 (2013).

23. *See* Cindy W. Christian, *AM. ACAD. PEDIATR.* et al., *Understanding Abusive Head Trauma in Infants and Children* 5 (2015).

24. *See, e.g., id.*; Alex V. Levin et al., *The Eye Examination in the Evaluation of Child Abuse*, 126 *PEDIATRICS* 376 (2010).

25. *See, e.g.*, Swedish Report, *supra* note 19, at 6.

26. M. Mattheij et al., *Retinal Haemorrhages in a University Hospital: Not Always Abusive Head Injury*, 117 *ACTA NEUROL. BELG.* 515 (2017).

27. Robert W. Hollenhorst et al., *Ocular Signs and Prognosis in Subdural and Subarachnoid Bleeding in Young Children*, 60 *ARCH. OPHTHALMOL.* 187 (1958).

28. Evan Matshes, *Retinal and Optic Nerve Sheath Hemorrhages Are Not Pathognomonic of Abusive Head Injury*, 16 *PROC. AM. ACAD. FORENSIC SCI.* 272 (2010).

29. *See* Leestma, *supra* note 13, at 619.

30. A.O. Mulvihill et al., *An Inter-Observer and Intra-Observer Study of a Classification of RetCam Images of Retinal Haemorrhages in Children*, 95 *BR. J. OPHTHALMOL.* 99 (2011).

31. *See State v. Jacoby*, Ind. No. 15-11-0917-1, 2018 WL 5098763 (Sup. Ct. N.J. Aug. 17, 2018). ■

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DETERMINING RF COVERAGE IN CRIMINAL CASES

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Conclusion

The current method of determining coverage area for cell sites by drawing an arbitrary circle or arc around the cell site is not a scientific method and should not pass the *Daubert* or *Frye* test. A better method presented here has been used by cellular RF engineers for many years and uses a combination of modeling and measurements to determine actual coverage. Many criminal and civil cases depend on accurate and scientific information about cellphone location. People's lives depend on the outcome. The most accurate method available should be utilized to make sure justice is properly served.

Notes

1. *Carpenter v. United States*, 138 S. Ct. 2206 (2018).

2. *United States v. Carpenter*, 819 F.3d 880, 885 (6th Cir. 2016).

3. *United States v. Davis*, 785 F.3d 498 (11th Cir. 2015).

4. *Id.* at 503.

5. *People v. Superior Court of Los Angeles County; Ronald Brim*, Real Party in Interest, B229701, <https://caselaw.findlaw.com/ca-court-of-appeal/1560782.html>.

6. *Daubert v. Merrell Dow Pharmaceuticals*, 113 S.Ct. 2786 (1993).

7. *Frye v. United States*, 293 F. 1013 (D.C. Cir. 1923).

8. FCC Electronic Code of Federal Regulations, <https://www.ecfr.gov/cgi-bin/text-idx?SID=b7dbb5d84aa010f5ed384dea0fcf1cd&mc=true&node=sp47.1.2j&rgn=div6>. ■

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Richard Miletic has been in the wireless field for over 30 years. He helps with network design, testing and troubleshooting for cellular, Wi-Fi and public safety systems. He provides expert testimony in criminal and civil cases all over the United States.



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