

COMMENTARY

A Critical Appraisal of the Systematic Review on Adverse Events Associated With Pediatric Spinal Manipulative Therapy: A Chiropractic Perspective

Joel Alcantara, BSc, DC¹

Abstract

The purpose of this paper is to provide a critical appraisal of the systemic review on adverse events associated with pediatric spinal manipulative therapy performed by Vohra and colleagues. This appraisal of their work will reveal some startling facts that were not addressed and/or left out. Many adverse effects were made out to be minor, moderate, or severe, when in fact they are all minor events that are easily addressed by the chiropractor. Vohra and her colleagues paint a picture that solely blames chiropractic for the adverse effects experienced in these cases. The paper by Vohra et.al. is lacking in that it does not address an appreciation of the variety of techniques in performing SMT on pediatric patients.

Key Words: *Chiropractic, systemic review, pediatric, spinal manipulative therapy, adjustment*

Introduction

The ever-increasing use of complementary and alternative medicine (CAM) by children has been recognized by the American Academy of Pediatrics (AAP). As part of their response to this finding, the AAP has charged the Task Force on Complementary and Alternative Medicine to develop resources to educate medical physicians, patients and families. Towards this end, Kemper and colleagues¹ addressed the issue by describing many aspects of CAM for children including an outline of the common types of complementary and alternative medicine therapies. Safety and effectiveness are foremost for all healthcare providers.

On the issue of the chiropractic care of children or more precisely, on the safety of pediatric chiropractic, according to Kemper and colleagues, “Although anecdotal data suggest that severe complications are possible with chiropractic treatment of infants and children, such adverse effects seem to be rare.” To support this statement, Kemper and colleagues¹ referenced the systematic review by Vohra and colleagues.² However, when the study by Vohra and colleagues was first published, comments made by Dr. Sunita Vohra and the conclusion of their study provided those with anti-chiropractic sentiments an opportunity to denigrate chiropractic and instill fear in parents on this holistic and vitalistic approach to children’s health.

1. Research Director, International Chiropractic Pediatric Association and Private Practice of Chiropractic, San Jose, CA, USA

An article by Amy Norton³ reads, “Spinal Manipulation May Not Be Safe for Children.” Norton interviewed Dr. Sunita Vohra for her article and quoted as stating, “We found more harms associated with delayed diagnosis and/or treatment than with manipulation itself.” Vohra was also indicated as advocating that parents should first talk to their child's pediatrician about any symptoms, in order to rule out any serious problem. From a biomedical ethics and chiropractic perspective, such comments are unacceptable. Vohra and her colleagues² are to be commended at their attempt to fill the “virtually non-existent” database on this aspect of children's care. However, a critical appraisal of their article and updates on the subject will reveal some startling facts that were not addressed by Vohra and her colleagues.

Methods

In their systematic review of the literature, Vohra and colleagues¹ searched the following electronic databases: Central [Second Quarter, 2004], Medline [1966-2004], PubMed [1966-2004], Embase [1988-2004], CINAHL [1982-2004], AltHealth [1990-2004], MANTIS [1900-2004] and ICL [1985-2004]. The literature review spanned a period from 1900 to 2004 covering 104 years of published literature.

Their initial search identified a total of 13,916 possible articles for consideration. An initial screening defined 164 articles for full review with another 68 articles garnered from a review of the reference lists and by contacting authors of included reports and experts in the field. Applying their study selection criteria (see Table 1), they identified 13 studies – 10 from the English language, 2 in French and 1 German article. From these 13 studies, Vohra et.al.² were able to identify 14 cases of direct adverse events associated with spinal manipulative (SMT) of children. They further subcategorized these events as minor, moderate, or severe adverse events and delayed diagnosis or treatment (see Table 2). Of the 14 cases, 10 were associated with chiropractic care. This is not surprising given that SMT is the primary approach to patient care – pediatric or adults. It is these 10 chiropractic cases that are of interest in this article along with the referenced literature that Vohra and colleagues² attributed harm due to delayed diagnosis and delayed treatment by chiropractors. Interestingly, Vohra and colleagues² commented that they found 32 articles that did not identify an adverse event associated with pediatric SMT. From this alone, one may comment that the literature supports lack of harm more than adverse events.

Review of Literature

An examination of the literature begins with the two articles reporting 3 MINOR adverse events associated with chiropractic SMT. The first, by Sawyer et.al.⁴ involved a pilot study examining the feasibility of conducting a full-scale clinical trial to examine the efficacy of chiropractic SMT in children with otitis media. Sawyer et al.⁴ reported the following: “There were no serious side effects as a result of either the active or placebo chiropractic treatments. One parent in the active group reported their child had some mid-back soreness after one treatment that resolved after a few days, and another child was reported by the parent as being irritable for a short time after treatment.”

The second article, by Klougart et.al.⁵, was a survey of Danish chiropractors to estimate the occurrence of cerebrovascular events after chiropractic treatment to the cervical spine. In their report, Klougart et. al.⁵ described a 10-year old male with an initial complaint of headaches and nausea. The patient received chiropractic SMT described as the Gonstead Technique to the C₇/T₁ vertebral bodies on 2 separate occasions. On each occasion the patient loss consciousness after the adjustment. An adverse event involving soreness and stiffness at the site of the adjustment are nothing new to chiropractors or their patients. For most, these are minor events that are easily addressed by the attending chiropractor.

For example, a modification of technique and/or its application to a different segment as well as providing adjunctive therapy in the way of soft-tissue work (i.e. massage, myofascial release, etc.) will address the problem. What is interesting is the interpretation on the part of Vohra and her colleagues² that a child described as “irritable” following chiropractic care would be interpreted as an adverse event. On what basis do the authors make this interpretation? What of syncope following the adjustment? I know of several chiropractors with patients who demonstrate a vaso-vagal response to SMT in the cervical spine resulting in “fainting” or loss of consciousness. In these cases, the patient indicated a history of “fainting” with a turning of the head and neck in various situations with no adverse events. Obviously, the 10-year-old patient or his parents were not dissuaded from care following the first event of syncope. Therefore, the interpretation on the part of Vohra and her colleagues of an adverse event in this situation is also questionable.

Vohra et.al.² reported on 2 patients experiencing MODERATE adverse events associated with chiropractic SMT. Both of these patients were reported in the study by LeBoeuf et.al.⁶ This study followed 171 enuretic children (aged 4-15 years) and their response to chiropractic care. The study was performed in a chiropractic college teaching clinic with 5th year interns providing chiropractic care under the supervision of a licensed clinician. With respect to adverse events, LeBeouf et.al.⁶ reported the following: “One child developed severe headaches and a stiff neck after treatment of the cervical spine and neither the child nor the parents could recall any previous symptoms from that area. The condition improved gradually over the next two weeks during which soft tissue therapy was administered and the child refrained from active physical activity. The other subject developed acute pain in the lumbar spine similar to the case described previously and recovered while gentle treatment was provided for symptomatic relief.” According to Vohra and colleagues, a moderate adverse event involves “transient disability involving seeking medical care but not hospitalization.” Clearly the adverse events described in the LeBoeuf et.al.⁶ article are minor rather than moderate adverse events. Stating the obvious, Vohra and her colleagues incorrectly applied their own adverse event subtyping. Furthermore, the study by LeBeouf et.al.⁶ is a prospective study rather than a randomized clinical trial (RCT), as incorrectly identified by Vohra et. al.¹

The discussion now turns to those articles presented by Vohra and colleagues as SERIOUS adverse events and attributed to chiropractors. Note that the paper by Held,⁷ an article from the French literature, was not readily retrievable and not included

for our discussion. L'Ecuyer⁸ described the case report of a 12-yr-old girl "who sustained several episodes of head-neck trauma, followed on two occasions by vigorous chiropractic "adjustments."

Table 3 provides the relevant historical patient information on the case referred to by L'Ecuyer.⁸ From cause and effect inferences, Table 3 highlights the many confounding variables that question the validity of attributing the patient's adverse events solely to the chiropractor. The least of these include a history of several traumatic events to the patient's head and neck resulting in neurological trauma prior to presenting to the chiropractor. Additionally, L'Ecuyer described the results of the first set of chiropractic care as causing "further pain" and yet, on the next traumatic event befalling the patient, the girl's parents again sought chiropractic care for their child. The patient was eventually diagnosed, based on x-ray studies with: 1) Congenital occipitalization of the atlas with subsequent injury to the craniocervical region of the spinal cord causing pyramidal tract signs and symptoms in this unusually susceptible situation, 2) Congenital torticollis, and 3) Possible refractive error.

Vohra et. al.¹ described the adverse event associated with this case as: "neck pain and progression to unsteady gait, poor coordination, drowsiness and hospitalization, delayed diagnosis of congenital occipitalization." Did chiropractic care really cause these adverse events? Could a history of trauma to the cranium and cervical spine offer a plausible alternative explanation to the child's symptoms? What evidence did Vohra and her colleagues have that the chiropractor failed to or misdiagnosed congenital occipitalization? The answer – none.

Another case was described by Zimmerman et.al.⁹ The details of the case for consideration are provided in Table 4. Zimmerman et.al.⁹ commented that the child "exhibited changing neurologic signs to the posterior cerebral circulation after gymnastics and chiropractic treatments." Vohra and her colleagues painted a very different picture with blame placed solely on chiropractic. Vohra and her colleagues described the time to adverse event as "several hours post-treatment" but failed to further point out that the patient suffered neurologically prior to chiropractic care and described by Zimmerman and colleagues⁹ as occurring often following the patient's gymnastics in which the patient attempted mid-air summersaults, "landing on the occiput and cervical spine." This was not only misleading and irresponsible on the part of Vohra and her co-authors but also reflection of their lack of appraisal skills.

Another case of severe adverse events attributed to chiropractic SMT was presented by Ziv et.al.¹⁰ The patient was a 12-yr-old girl with osteogenesis imperfecta. The patient had a history of multiple fractures of the limbs. Prior to presenting to the chiropractor, no timeline provided, the patient's family had noticed that the patient had a "gradual sagging chin after a minor fall at school." The child was taken to the chiropractor because of headaches, and pain in the neck and low back that interfered with her everyday activities. Two weeks after her visit to the chiropractor, the patient experienced deterioration of powers in the legs accompanied by clonus at rest, urinary urgency and frequency. Motor

paraplegia developed and three weeks later she was admitted to the hospital. Whether this was 5 weeks post-chiropractic visit was not specified in the article. At the hospital, reconstructed computerized tomography demonstrated severe progressive spondyloptosis at the cervicothoracic junction, fracture of the C₇ pedicles and complete blockage of CSF at this region.

According to Vohra et.al., the adverse event involved progressive neuromuscular deficits in the lower extremities with clonus at rest, urinary urgency, and frequency as well as paraplegia. Regardless of the patient's pre-existing osteogenesis imperfecta, a history of multiple fractures of the limbs and prior to presenting to the chiropractor, a fall that resulted in a "sagging chin." Vohra et.al.¹ attributed the declining neurological status of this patient wholly to the chiropractic visits and imply that a delayed or misdiagnosis of osteogenesis imperfecta on the part of the chiropractor.

What is interesting is that Ziv et.al.¹⁰ commented of their awareness that the most common spinal problems in patients with osteogenesis imperfecta are spinal deformity and brittleness of the bone resulting in fractures, particularly compression fractures, and brainstem compression and hydrocephalus. Had Vohra et.al.¹ been more clinically astute and objective about the nature of the patient's pre-existing diagnosis, her history of trauma and declining neurological status, they may not have been so quick to attribute blame solely to chiropractic.

The last case report attributed to a chiropractor resulting in a serious adverse event was that reported by Shafir et.al.¹¹ According to Shafir and Kaufman,¹¹ they attributed a 4-month-old boy's clinical deterioration to the chiropractor based on "the close temporal relationship between the visit to the chiropractor and the decline of the patient." Let us examine some details of the case.

The boy was admitted to the hospital some three hours after his last visit to the chiropractor. He was described as listless and fussy, with a weak cry. Shafir and Kauffman described the chiropractic care as "neck manipulation", and further described as "manipulation that included flexion, extension and axial loading and unloading." In the hospital, the patient continued to deteriorate. A chest x-ray identified an enlargement of the spinal canal from C₃-T₈. Magnetic resonance imaging demonstrated a mass within the spinal cord, extending into the medulla superiorly and occupying the entire canal from the mid-cervical to the lower thoracic region. The patient underwent surgery.

The resection of the intraspinal mass was described at the C6 vertebral level as creamy white, viscoelastic tumor tissue that exuded spontaneously. The cervical and lower thoracic portions of the tumor were easily separated from normal-appearing spinal cord tissue, but no normal cord tissue was identifiable at the mid-thoracic level. A gross total tumor resection was accomplished. The pathologic examination revealed mostly necrotic tissue and low-grade astrocytoma.

Vohra and her colleagues described the adverse event suffered by this patient as "quadriplegia secondary to spinal cord astrocytoma and spinal manipulation; regressed to

paraplegia, 18 months postoperatively.” Again, Vohra et.al., like Shafir et.al.,¹¹ attributed the adverse events solely to the chiropractor. Although temporal association is a criteria for cause and effect, it is not the only criteria.

Discussion

Cause and effect inferences require several factors to be addressed. One of which certainly is a temporal association. However, temporal association alone does not lead to cause and effect. Other variables such as biological plausibility, dose effect, strengths of association, etc. are required to make cause and effect inferences.

Given the extent of tumor infiltration, described mostly as necrotic tissue, to the patient’s cervical and thoracic spine, I would suggest that biological plausibility alone puts into question the patient’s declining status as a result of chiropractic care.

Vohra and her colleagues² further identified “20 cases of delayed diagnosis and/or inappropriate provision of chiropractic care.” Seven cases involved delayed treatment of cancer, two cases involved delayed treatment of meningitis, and one case involved delayed treatment for embryonal rhabdomyosarcoma. The supporting documents are from 3 references – by Turow et.al.,¹² Nickerson et.al.¹³ and Smith.¹⁴ Let us examine what the data really shows.

The paper by Turow¹² described two cases. One involved an 18-yr-old male with complaints of low back pain cared for by a chiropractor. Following 2 months of care, his parents took the patient to the hospital. After extensive testing, the patient was diagnosed with choriocarcinoma that had metastasized from the retroperitoneal region of the abdomen to the kidneys, liver, and lungs. The second case involved a 13-year old-boy brought into the hospital due to a 5-day history of swelling of the right thigh.

According to Turow,¹² the patient was treated by a chiropractor during “a 6 week period”, exact date and time prior to presenting to the hospital not specified, for hip misalignment and hip dysplasia. The patient was medically diagnosed with “aggressive osteosarcoma.” According to Turow,¹² when the parents were informed of the diagnosis, they attempted to remove the child from the hospital, citing “distrust of doctors” and faith in the chiropractor. Child Protective Services was averted when the parents agreed to show the x-ray films to the chiropractor that urged hospital treatment. The article by Turow is a Letter to the Editor in the Archives of Pediatric and Adolescent Medicine. Vohra and her colleagues did not follow their own Study Selection eligibility criteria for relevant articles for their study and provides weak evidence to support their contention of harm on the part of chiropractic.

The second paper was by Nickerson and Siberman.¹³ The article is also a Letter to the Editor in The Journal of Pediatrics. Of the 20 cases cited by Vohra et.al.¹ that resulted in a delayed diagnosis and/or inappropriate provision of chiropractic care, 14 (70% of the cases) of these cases are from this three paragraph Letter to the Editor wherein Nickerson and Siberman share with the readership their tale of

harm as a result of children receiving chiropractic care. The last reference cited by Vohra et.al.² is the 1969 textbook by Smith¹⁴ entitled, “At Your Own Risk: The Case Against Chiropractic.” Again, Vohra et.al. ignored their own study selection eligibility criteria to cite this anti-chiropractic textbook from 1969.

Interestingly, the references by Smith¹⁴ along with the 1969 paper, with the same title, by Sabatier¹⁵ were nothing more than a diatribe, in a Letter to the Editor format, against chiropractic from Sabatier, the Chairman of the AMA Committee on Quackery, at that time. In his diatribe, Dr Sabatier did not cite one case involving adverse events associated with pediatric spinal manipulation. However, Vohra et.al.¹ thought it worthwhile to include as supporting reference against SMT in the care for children.

According to Vohra et.al.,¹ the spontaneous reporting of adverse events associated with any healthcare procedure or more specifically, the lack of properly designed studies, like RCT’s and longitudinal studies, to address such issues may underestimate risks. Furthermore, the lack of quality and quantity of these spontaneous reports limits assessment of causation. So why then did Vohra et.al. choose to make the concluding comments that “serious adverse events may be associated with pediatric spinal manipulation.....?” Given the lack of quantity and quality of evidence documenting harm attributed to SMT of children, and the questionable interpretation, and misrepresentation of data on the part of Vohra and her colleagues, we can argue that the conclusion of their study was inappropriate.

Evidence-based practice is dependent not only the existing literature, i.e. published systematic research, but also the clinical expertise and patient’s or parents’ wishes. Yes, studies are lacking in making risk assessments on the use of SMT in the pediatric population. However, we in the chiropractic profession have over 100 years of clinical experience on the chiropractic care of children. I would assert that chiropractors perform SMT procedures more than any other healthcare profession. Rather than deriving expert opinion from those within the chiropractic profession and cite the many references indicating appropriateness and safety of pediatric chiropractic, Dr. Vohra and her colleagues chose to point out that pediatricians “believe that the use of spinal manipulation on children is dangerous and advise against its use.” This is akin to chiropractors being asked their expert opinion on the safety and appropriateness of cosmetic surgery.

For the benefit of Dr. Vohra and colleagues, our experience with pediatric chiropractic is that it is relatively safe. It is relatively safe when you compare SMT in children against “off-label” medication in children.¹⁶ Again, one must agree that risk assessment and cause and effect inferences are inappropriate based on the heterogeneity of the data examined.

However, Caeteris paribus – given that all things are equal – some 30 million visits were made by children to chiropractors in 1997.¹⁷ Indications are that this trend is increasing with subsequent years as reported by Barnes and colleagues.¹⁸ According to Barnes and colleagues, the most popular practitioner-based complementary and alternative medicine for children was chiropractic in 2007.¹⁸ The paper by Vohra et.al.

would seem to point more towards rare events rather than underreporting.

On the subject of risk factors, Vohra et.al. attributed predisposition to adverse events as a result of spinal manipulative procedures on 1) immaturity of the spine, 2) rotational manipulation, and 3) high-velocity spinal manipulations. First, its amazing that the authors caution on the inappropriateness of making risk assessments, cause and effect inferences, and incidence rates when it comes to adverse events associated with SMT in children. However, based on 4 cited references, they find it acceptable to comment on risk factors that predispose children to adverse events as a result of SMT. Insofar as I am aware; most studies on risk for stroke with SMT have been done on adults – not children. Furthermore, studies on risk begin with an examination of risk indicators. These involve RCT's and population-based studies as well as a thorough review of the literature.

I wholeheartedly disagree with Vohra et.al. in that these comments on risk factors are unsubstantiated, are overly simplistic and does not take into account the unique aspect of performing SMT on this patient population. First, the care and use of SMT on pediatric patients is simply not a scaled-down version for an adult. The pediatric spine has unique biomechanical properties which must be taken into account when performing SMT. Pediatric spine characteristics such as maleability and adaptibility alone indicate spinal resiliency.

However, given the immaturity of the musculoskeletal system, HVLA-type maneuvers are tempered with respect to the forces applied. The paper by Vohra et.al. is lacking in that it does not address an appreciation of the variety of techniques in performing SMT on pediatric patients. Furthermore, given the pediatric spine's hypermobility, rotational manipulation as interpreted from adult studies are inappropriate. Until these issues are addressed more fully, comments on risk factors, or more appropriately on the possible risk indicators, for SMT on children are inappropriate.

Conclusion

In closing, I would like to make one further comment. Vohra et.al. have made misguided comments about collaboration with pediatric experts to address direct and indirect adverse events in the care of pediatric patients with SMT. Yes, collaboration would benefit all our patients – adults and children; but to attribute these adverse events because we in chiropractic lack “sufficient pediatric training” shows their lack of understanding on the theoretical and clinical framework from which we provide chiropractic care for children.

We again point out the findings of Lee and colleagues,¹⁷ “Pediatric chiropractic care is often inconsistent with recommended medical guidelines.” Of the many precedents established by Wilk vs. the AMA, foremost is that chiropractic is a separate and distinct healthcare profession. Our patients and their children seem to understand this and seek out our services. Vohra and her colleagues think otherwise. The Task Force on Complementary and Alternative Medicine admonish clinicians on the 4 basic principles of biomedical ethics: 1) respect for patients' autonomy; 2) nonmaleficence, avoiding

harm; 3) beneficence, putting the patient's interest and well-being first; and 4) justice, fairness in providing access to essential care.¹ In the interest of integrative medicine and the care of all patients, we ask all to heed these principles.

References

1. Kemper KJ, Vohra S, Walls R, Task Force on Complementary and Alternative Medicine, Provisional Section on Complementary, Holistic and Integrative Medicine. American Academy of Pediatrics. The use of complementary and alternative medicine in pediatrics. *Pediatrics* 2008;122(6):1374-86.
2. Vohra S, Johnston BC, Cramer K, Humphreys K. Adverse events associated with pediatric spinal manipulation: a systematic review. *Pediatrics*. 2007 Jan;119(1):e275-83. Epub 2006 Dec 18.
3. Amy Norton. Spinal Manipulation may not be Safe for Children. Jan 12, 2007. Accessed June 6, 2009 www.reuters.com/article/healthNews/idUSKNE27049020070112
4. Sawyer CE, Evans RL, Bolin PD, Branson R, Spicer A. A feasibility study of chiropractic spinal manipulation versus sham spinal manipulation for chronic otitis media with effusion in children. *J Manipulative Physiol Ther*. 1999 Jun;22(5):292-8.
5. Klougart Klougart N, Leboeuf-Yde C, Rasmussen LR. Safety in chiropractic practice. Part II: Treatment to the upper neck and the rate of cerebrovascular incidents. *J Manipulative Physiol Ther*. 1996 Nov-Dec;19(9):563-9.
6. Leboeuf C, Brown P, Herman A, Leembruggen K, Walton D, Crisp TC. Chiropractic care of children with nocturnal enuresis: a prospective outcome study. *J Manipulative Physiol Ther*. 1991 Feb;14(2):110-5.
7. Held JP. Dangers of cervical manipulation in neurology [in French]. *Ann Med Phys (Lille)*. 1966;251-259.
8. L'Ecuyer JL. Congenital occipitalization of the atlas with chiropractic manipulations: a case report. *Nebr State Med J*. 1959; 44:546-549.
9. Zimmerman AW, Kumar AJ, Gadoth N, Hodges FJ 3rd. Traumatic vertebralbasilar occlusive disease in childhood. *Neurology*. 1978;28:185-188.
10. Ziv I, Rang M, Hoffman HJ. Paraplegia in osteogenesis imperfecta. *J Bone Joint Surg Br*. 1983;65:184-185.
11. Shafir Y, Kaufman BA. Quadriplegia after chiropractic manipulation in an infant with congenital torticollis caused by a spinal cord astrocytoma. *J Pediatr*. 1992;120:266-268.
12. Turow VD. Chiropractic for children. *Arch Pediatr Adolesc Med*. 1997;151:527-528.
13. Nickerson HJ, Silberman TL, Theye FW, Rushig DA. Chiropractic manipulation in children. *J Pediatr*. 1992;121: 172.
14. Smith RL. *At Your Own Risk: The Case Against Chiropractic*. New York, NY: Simon & Schuster; 1969.
15. Sabatier JA. At your own risk: the case against chiropractic. *JAMA*. 1969;209: 1712.

16. Choonara I, Conroy S. Unlicensed and off-label drug use in children: Implications for safety. *Drug So* 2002;25:1-5.
 17. Lee AC, Li DH, Kemper KJ. Chiropractic care for children. *Arch Pediatr Adolesc Med* 2000; 154(4):401-407.
 18. Barnes PM, Bloom B, Nahin RL. Complementary and alternative medicine use among adults and children: United States, 2007. *Natl Health Stat Report* 2008; 12(1):1-23.
-

Table 1. Selection criteria by Vohra et.al.²

Criteria #	
1	The study was a primary investigation/report (i.e., case report, case series, case control, randomized controlled trials, and survey or surveillance studies)
2	Part or all of the study population was 18 years or younger
3	Adverse events were reported

Table 2. Classification of Adverse Events According to Vohra et.al.²

Adverse Event Classification	Definition
Minor	Self-limited, did not require additional medical care
Moderate	Transient disability involving seeking medical care but not hospitalization
Severe	Indicating Hospitalization, permanent disability, mortality
Delayed Diagnosis or Treatment	Involving Moderate to Severe Adverse Event as defined above that resulted in delayed medical diagnosis and/or treatment

Table 3. Events of the case described by L'Ecuyer⁸

Timeline	Relevant Historical Information
Prior to 1957	<ul style="list-style-type: none"> • Noted to “hold her head funny” with her head tilted to the right and chin to the left • At 8 years of age, burning and watering of the eyes • An oculist determined she did not require glasses • 1-2 frontal headaches per week which occur at the end of the day
Summer of 1957	<ul style="list-style-type: none"> • Fell from her upper-bunk bed hitting her head • Vomited once without further neurological symptoms
May 1958	<ul style="list-style-type: none"> • “the patient was accidentally crushed in a collision of several playmates from which she fell backward to the ground. It is not certain whether there was any unconsciousness, but she was able to walk five minutes later (“with some dizziness”).” • In the afternoon following the collision with playmates, the patient complained of neck pain and taken to a chiropractor who performed an “adjustment” then and on three subsequent days. The adjustments were described as “rapid twisting movements and jerks, causing, according to her mother, “cracking sounds.” The adjustments caused further pain and discontinued after the fourth of the series.
August 2, 1958	<ul style="list-style-type: none"> • “The patient fell while riding her bicycle and struck the back of her head. She had no neurological signs but complained of neck pains • Taken back to the chiropractor who “again performed a series of adjustments with the same outcome.”
August 8, 1958	<ul style="list-style-type: none"> • Patient unable to tie her shoes or button her dress, was clumsy, had an unsteady gait and seemed drowsy • The above symptoms had continued with some progression during the two weeks prior to her admission
August 22, 1958	Admitted to the University of Nebraska Hospital “because of gait abnormality of three weeks duration and headaches lasting two years.”

Table 4. Case description of the patient by Zimmermann et.al.⁹

Timeline	Relevant Patient Description
Prior to visiting the Chiropractor	<ul style="list-style-type: none"> • A 7-yr-old boy with recurrent unilateral headaches • Headaches occurred on either side without prodrome, on either side, once or twice a week, OFTEN following gymnastics exercises in which he attempted mid-air summersaults, landing on the occiput and cervical spine
Visit(s) to the Chiropractor	<p>According to Zimmerman et.al. (12),</p> <ul style="list-style-type: none"> • the chiropractor diagnosed cervical malalignment and initiated a course of rapid manual rotations of the head from side to side with flexion and hyperextension.
Several hours after a “particularly vigorous session	<ul style="list-style-type: none"> • ”the child suddenly became ill with a severe occipital bifrontal headache, vomiting, and left facial weakness
Next Day	<ul style="list-style-type: none"> • Neurologist found no abnormalities on examination • EEG and skull radiograms were normal
Chiropractic care restarted	<ul style="list-style-type: none"> • Treatment only to the lumber spine for two weeks • After two weeks, cervical manipulations were resumed. Accompanied by increasingly severe and persistent headache along with intermittent vomiting and diplopia for two weeks before admission
Hospital Admission	<p>Laboratory Studies</p> <ul style="list-style-type: none"> • Complete Blood Count, ESR, Urinalysis, Fasting an 2 hr postprandial glucose, serum electrolytes, serum urea nitrogen, creatine phosphokinase, etc. – all negative or normal • CSF Pressure – normal • CSF cultures and syphilis tests – Negative • Clotting studies –Normal • Chest x-rays, x-rays of the skull and cervical spine – normal <p>Neuroradiologic Studies</p> <ul style="list-style-type: none"> • Right vertebral angiogram by transfemoral catherization showed a filling defect at the distal portion of the basilar artery • Left vertebral transfemoral angiogram demonstrated a complete occlusion of the left vertebral artery at the middle of the body of C2