

Neck Adjustment: Benefits and Safety

The mandate of the Chiropractors' Association of Australia (CAA) and its members¹ is to make the care of patients their first concern, to practise safely and effectively, and to maintain a high level of professional competence and conduct that is essential for good care.

Part of the core values of the Chiropractors' Association of Australia (CAA) is to value the importance of intellectual honesty, scientific and academic excellence and the maintenance of integrity in serving the individual, the community and the chiropractic profession.

OVERALL SAFETY AND EFFICACY OF CHIROPRACTIC ADJUSTMENT

The objective of chiropractic adjustment is to restore, maintain and improve health and wellbeing. It does this by using the mechanical nature of the adjustment to make an input into the nervous system to assist the body to return to optimal function. Chiropractors determine where best to deliver an adjustment by looking for very small changes in a joint's biomechanical function, along with other clinical evidence such as changes in the function of the nervous system and the body's muscles, connective tissues such as tendons and ligaments, and various vascular structures. Often a dysfunctional joint will produce discomfort and pain in the joint and associated tissue; however, even in the absence of pain, your chiropractor may still be able to identify clinical findings that indicate chiropractic adjustment should be considered.

The safety and effectiveness of chiropractic spinal adjustment has undergone considerable scrutiny from individuals and organizations within the health care and scientific communities, as well as from chiropractors themselves. Few health-care interventions have been assessed as extensively. All objective assessment is welcomed by the profession.

The result of this extensive study is a significant body of evidence surrounding the efficacy of chiropractic care². Over the last 25 years, at least five formal government studies from around the world have found spinal adjustment therapy to be safe, effective and cost-effective³.

Complementing the government inquiries are numerous scientific and clinical studies (including randomized controlled trials) assessing the appropriateness, effectiveness and cost-effectiveness of chiropractic spinal adjustment⁴.

EVALUATING THE RISK

Neck adjustment (chiropractic spinal adjustment, or manipulation, of the cervical vertebrae from C1 to C7) is a precise procedure, generally applied by hand. It has been shown to improve joint

mobility in the neck, restoring range of motion and reducing muscle hypertonicity, and thereby, relieving pressure and tension.

In relation to the risk of stroke associated with neck adjustment, the CAA believes it is valuable to provide our members and the public with timely, accurate information that will enable them to continue to weigh the relative risks and benefits of the treatment options which typically include one or more of: (1) doing nothing to relieve a pain condition or joint dysfunction which may be or may become chronic; (2) use of medication to relieve symptoms; (3) neck adjustment; and (4) surgical intervention.

Unfortunately, much of the information now available to the public is based on faulty or biased research⁵. Many studies on the incidence of stroke are flawed or lack credibility. The problems with these studies include:

- (1) the results are inconsistent with the exhaustive, systemic literature reviews⁶;
- (2) chiropractic treatment is singled out as having an “unacceptable” or “inappropriate” risk while precipitating events and predisposing factors unrelated to cervical adjustment (such as sports and lifestyle activities, previous neck injury, disease and congenital anomaly) are undervalued or ignored;
- (3) neck adjustment is assumed to be a cause, or even the cause of stroke without any effort to identify whether that assumption is valid or what the causal connection might be; the research currently available is not capable of making a causal connection between neck adjustment and stroke;
- (4) the published natural causes of stroke are not recognized and accounted for; and
- (5) no or insufficient attention is given to the nature of the adjustment involved in the treatments at issue.

There are, however, more recent studies that provide a more careful and complete consideration of the safety of neck adjustment. According to these studies, the risk of stroke is actually quite small.

In the 2001 version of *Current Concepts in Vertebrobasilar Complications following Spinal Manipulation*, Dr. Allan G. Terrett assumed a risk of stroke of one in 2,000,000 patient treatments based on a comprehensive review of the existing literature concerning the incidence of stroke following neck adjustment⁷. Research recently published in the *Canadian Medical Association Journal* reports the risk at one in 5,000,000 patient treatments⁸. In 1996, the journal *Spine*, published “Manipulation and Mobilization of the Cervical Spine: a systematic review of the literature”⁹ in which the risk of stroke was stated to be between one and two per 1,000,000 treatments. These estimates are far below the risks commonly associated with many other medical and pharmaceutical interventions¹⁰.

Strokes occur all too often in the general population. The Australian National Stroke Foundation website reports as follows: “Stroke is Australia’s second single greatest killer after coronary heart disease and a leading cause of disability. In 2010, Australians will suffer around 60,000 new and recurrent strokes – that’s one stroke every 10 minutes”¹¹. Nevertheless, the websites of the National

Stroke Foundation of Australia and its counterparts in the U.K, and the U.S. – the Stroke Association (U.K.) and the American Stroke Association – do not reference neck adjustment as a factor contributing to the risk of stroke¹².

A COMPARISON OF RISK - DEVELOPING PERSPECTIVE

Almost all researchers and scientists studying this issue agree that whatever the risk of stroke in association with neck adjustment, it is exceedingly rare. Recent studies (see “Evaluating the Risk” above) indicate the risk can be conservatively estimated at one in every 1,000,000 procedures. This is significantly lower than risks that have been reported for other commonly utilized health care procedures:

Strokes from birth control pills = 1 in 24,000 persons¹³

Fatalities caused by NSAIDS (Aspirin, Naproxen, Ibuprofen, Motrin) = 1 in 1,200 persons¹⁴

Fatalities in association with cervical spinal surgery = 1 in 145 surgeries¹⁵

It is also significantly lower than the risk of death associated with many activities of daily living¹⁶, for example:

Canoeing = 1 in 100,000 persons

Playing soccer – 1 in 25,000 persons

Automobile driving (United Kingdom) = 1 in 5,900

QUESTIONS AND ANSWERS ABOUT NECK MOVEMENT AND STROKE

How might neck movement be associated with stroke?

Over the years, researchers and health professionals have drawn an association between the onset of stroke symptoms and certain activities of daily living involving movement of the neck (see “Activities of Daily Living and the Risk of Stroke” below). In this context, an “association” means that the two events seem to occur at or near the same time, or in conjunction with one another, but there is no certainty that one event caused the other, or in fact, that the two events are in any way related. A dilemma for those seeking to determine the nature of the relationship between neck movement and stroke is that the incidents which led to the association being drawn – strokes occurring in conjunction with or following an activity of daily living involving neck movement – are relatively rare, and therefore, difficult to study and understand.

Nevertheless, current theories suggest that, in exceptional cases and likely when the individual has some unidentified predisposition, movement of the neck may start or contribute to a series of events leading to stroke.

According to this thinking, neck movement might disrupt the lining of one of the two vertebral arteries which, as indicated by their name, run up through the vertebrae of the neck and bring blood

to the back of the brain. As the disruption to the lining of a vertebral artery heals, a thrombus, or blood clot, can form. In some cases, blood can also collect in a pocket between the layers of the artery wall which expands and, either by itself or together with a thrombus, limits or blocks the flow of blood to the brain. When some or all of these events occur, a person may experience symptoms of stroke. Usually, though, these symptoms do not persist, and no permanent injury results.

A bigger concern is when small pieces of a thrombus break off and travel to the narrower arteries in the back of the brain, where they become lodged and cut off blood supply. This process can cause areas of brain damage known as infarcts and lead to the neurological symptoms and more lasting injury associated with “stroke”. One theory is that in some cases, instead of causing damage to the vertebral artery, neck movement may simply dislodge or break off pieces of a thrombus that was already present, either as a result of a prior injury or because of disease.

Who is susceptible to stroke in association with neck movement?

The science in this area is also evolving. The traditional risk factors of stroke (such as: poorly-controlled high blood pressure, obesity, smoking, family history of cardiovascular disease) are not necessarily risk factors for stroke in association with neck movement. They do not appear to be helpful indicators of who is at risk for the series of events described above. Emerging science points to connective tissue diseases (including: Ehlers – Danlos syndrome, Marfans syndrome, fibromuscular dysplasia, osteogenesis imperfecta and multiple exostosis syndrome) as a significant factor in the potential for arterial damage leading to stroke¹⁷.

What type of neck movement may lead to stroke in susceptible individuals?

Many seemingly benign, everyday activities that involve movement of the neck have been associated with strokes in susceptible individuals, including: turning of the head while reversing a vehicle; cradling a telephone handset between one’s ear and shoulder; overhead work; undergoing dental procedures; swinging a golf club; hanging up laundry; and, having one’s hair washed at a beauty salon.

ACTIVITIES OF DAILY LIVING AND THE RISK OF STROKE

Some of the activities of daily living associated with the onset of stroke symptoms include¹⁸:

- neck extension for a bleeding nose
- postural head changes
- hanging out washing
- turning head while backing up a car
- sleeping positions
- coughing
- stooping to pick up a bucket
- sightseeing, stargazing or watching aircraft
- tai chi
- emergency resuscitation
- cradling a telephone handset between ear and shoulder
- falls (minor)
- trampoline
- fitness exercise
- hair dressing
- yawning and vigorous stretching
- overhead work (painting ceiling)
- yoga

Can other factors or activities contribute to the potential for stroke?

Yes. Risks of stroke are inherent in certain medical procedures, pharmaceutical interventions and lifestyle activities. For instance, certain levels of tobacco and alcohol consumption are known to contribute to the potential for stroke. In addition, there is a one in 24,000 risk of stroke arising from use of the birth control pill¹⁹ (see “A Comparison of Risk – Developing Perspective” above).

How is neck adjustment related to stroke arising from neck movement?

Some researchers have suggested an association between the neck movement involved in neck adjustment and the occurrence of a stroke moments, minutes, hours, and in some cases, days later. Given the presumed association between neck movement and stroke (see the response to the question “How might neck movement be associated with stroke?” above, where it is noted that “in this context, an ‘association’ means that the two events seem to occur at or near the same time, or in conjunction with one another, but there is no certainty that one event caused the other, or in fact, that the two events are in any way related”), it is, perhaps, understandable why people might assume a cause-and-effect relationship, particularly when there is a relatively short interval between treatment and the onset of the neurological symptoms associated with stroke. However, there is presently no medical or scientific evidence effectively linking neck adjustment to stroke in a causal way.

The only research which has attempted to measure the physical effects of neck adjustment on the vertebral arteries contradicts the existence of any causal relationship. A 2002 study found that neck adjustment did not result in strain sufficient to damage the arteries, and in fact, may create less

strain than neck movement during common activities of daily living²⁰. Further, a 2008 study found that neck adjustment did not exacerbate pre-existing vertebral artery damage in canine subjects²¹.

On top of that, another 2008 study found almost the same rate of association between physician visits and stroke as was observed with chiropractor visits²². The similarity in the association suggests patients may be visiting their family doctors and chiropractors with head and neck pain caused by an artery that is already dissecting or damaged. Patients with a damaged artery typically experience severe and sudden neck pain that is unlike anything they have experienced before. Health-care practitioners, including chiropractors, must be alert to patients who attend at their clinics complaining of such symptoms. Careful questioning about the symptoms is essential. If there is uncertainty about the origin of the symptoms, delaying treatment is the right course of action. The chiropractor may also consider referral for medical evaluation.

What about damage to the carotid arteries?

Like the vertebral arteries, the carotid arteries pass blood through the neck to the brain. Some researchers have postulated a similar association between neck adjustment and dissection of the internal carotid artery, which, of the two carotid arteries, is anatomically closest to the upper vertebrae of the neck. However, an American study released in 2003 identified only 13 instances of carotid artery dissection occurring relatively close (in some cases, days) after a neck adjustment in the 34 years between 1966 and 2002. Comparing this number to the estimated number of chiropractic adjustments that occurred during that time, the researchers calculated the relative risk of carotid artery dissection following adjustment at 1 in 601,145,000. Accordingly, they concluded there was no cause and effect relationship between neck adjustment and carotid artery dissection²³.

Who is qualified to perform spinal adjustments?

Under the *Health Practitioner Regulation National Law Act 2009, s 123*,²⁴ the Australian government has designated health-care procedures involving spinal manipulation be restricted to only chiropractors and health professionals that have adequate post graduate qualifications/training. However the public must understand that these professionals are not equally qualified to deliver this treatment.

Chiropractors consistently maintain a high standard of education, training and experience with regard to performing spinal adjustment.

The chiropractic profession is the only health service provider group with spinal adjustment as its core education and practice. To minimize, prevent and possibly eliminate risks to the public, chiropractic education embarks on a very tedious, rigorous and extensive educational process, particularly in the application of adjustment as a treatment form. Chiropractic training in Australia involves five-year, University courses. These courses are of similar length and depth as medical courses, but focus on promoting healthier lifestyles via better body function, rather than on drugs and surgery. After entering practice, Australian Chiropractors are also required to undertake

continuing professional development to keep their skills current and stay up-to-date with the latest scientific research.

Without the same level of training, education and practice, other health professions with some competence in general manipulative therapy, cannot be expected to provide spinal adjustment with the same level of competence and safety as chiropractors, nor can they be expected to achieve the same results.

Before receiving spinal adjustment from a health-care professional other than a chiropractor, the CAA recommends that patients ask the practitioner concerned to explain in detail his or her particular training and competency to perform the intended procedure.

CONCLUSION

It is crucial that patient decision making is based on informed consent. The chiropractic profession has been vigilant in providing timely, accurate information to help patients evaluate their health care choices and weigh the relative risks and benefits of treatment options.

Recent research and scientific studies and government analyses continue to support the safety, efficacy and cost-effectiveness of chiropractic spinal adjustment. Despite the high profile given to the subject of treatment-related strokes, patient statistics reveal that increasing numbers of health consumers rely upon chiropractic as a safe, effective and non-invasive means of resolving head, neck and back pain, with over 215,000 Australians visiting a chiropractor each week²⁵.

Nevertheless, the CAA urges all health care consumers to thoroughly investigate the benefits and risks associated with every health procedure and pharmaceutical intervention, and reiterates its commitment to patient safety and well-being through established initiatives to raise public awareness, including:

- (1) engaging in open, honest dialogue with the public and the media;
- (2) providing accurate, thorough information on a timely basis;
- (3) ensuring that the risks and range of treatment options are fully disclosed to all patients; and
- (4) supporting the development of ongoing research into the benefits and risks of adjustment in the treatment of neck and back pain.

The CAA wishes to acknowledge the CCBC, who have kindly provided permission for us to reference their Position Document “Neck Adjustment: Benefits and Safety”

FOOTNOTES

¹ Registered Australian chiropractors are regulated by the Health Practitioner Regulation National Law Act 2009, together with the Chiropractic Board of Australia's Code of Conduct for Chiropractors. Copies of these documents are available at <http://www.chiropracticboard.gov.au/>

² February 15, 2001, the Canadian Chiropractic Association website: <http://www.ccachiro.org>.

³ Health Quality Council of Alberta. *Satisfaction with Health Care Services: A Survey of Albertans*. 2006. Ontario Workplace Safety and Insurance Board (WSIB) *Program of Care for Acute Lower Back Injuries: One-Year Evaluation Report*. 2004. *Chiropractic in the United States: Training, Practice and Research*, U.S. Department of Health and Human Services. AHCPR Research Report, 1997. Manga P, Angus D, Papadopoulos C, Swan W. *The Effectiveness and Cost-Effectiveness of Chiropractic Management of Low-Back Pain*. Ottawa: Kenilworth Publishing, 1993. Commission on Alternative Medicine. *Legitimization for Vissairopraktorer*. South Africa, 1987. Thompson CJ. *Medicare Benefits Review Committee*. Australia: Commonwealth Government Printer, 1986. Hasselberg PD. *Chiropractic in New Zealand, Report of the Commission of Inquiry*. Wellington: Government Printer, 1979 (see <http://www.ccachiro.org>).

⁴ **Chiropractic generally:** Choudhry N, Milstein A. *Do Chiropractic Physician Services for Treatment of Low Back and Neck Pain Improve the Value of Health Benefit Plans?* San Francisco: Mercer Health and Benefits, 2009. Legoretta AP, Metz RD, et al. Comparative Analysis of Individuals with and without Chiropractic Coverage: Patient Characteristics, Utilization and Costs. *Archive of Internal Medicine* 2004; 164: 1985-1992. United Kingdom back pain exercise and manipulation (UK BEAM) randomized trial: Cost effectiveness of physical treatments for back pain in primary care. *British Medical Journal* 2004. Mior S. Manipulation and mobilization in the treatment of chronic pain. *The Clinical Journal of Pain* 2001; 17:570-576. *Utilitation, Cost and Effects fo Chiropractic Care on Medicare Program Costs*. Washington: Muse & Associates, 2001. Waddell G, McIntosh A, Hutchinson A, Feder G, Lewis M. *Low Back Pain Evidence Review*. London: Royal College of General Practitioners, 1999. Mosley CD, Ilana GC, Arnold RM Cost-Effectiveness of Chiropractic in a Managed Care Setting. *The American Journal of Managed Care* 1996; 2: 280-282. Stano M, Smith M. Chiropractic and Medical Costs of Low Back Pain. *Medical Care* 1996; 34(3): 191-204. Meade TW, Dyer S, Browne W, Frank AO. Randomized Comparison of Chiropractic and Hospital Outpatient Management for Low Back Pain: Results from Extended Follow Up. *British Medical Journal* 1995; 311: 349-251. Manga P, Angus D, Papadopoulos C, Swan W. *The Effectiveness and Cost-Effectiveness of Chiropractic Management of Low-Back Pain*. Ottawa: Kenilworth Publishing, 1993. Ebrall PS. Mechanical Low-Back Pain: A Comparison of Medical and Chiropractic Management within the Victorian WorkCare Scheme. *Chiropractic Journal of Australia* 1992; 22(2): 47-53. Shekelle PG, Adams AH, Chassin MR, Hurwitz EL, Phillips RB, Brook RH. *The Appropriateness of Spinal Manipulation for Low Back Pain. Project Overview and Literature Review*. Santa Monica: RAND, 1991. Jarvis KB, Phillips RB, Morris EK. Cost per Case Comparison of Back Injury Claims of Chiropractic versus Medical Management for Conditions with Identical Diagnostic Codes. *Journal of Occupational Medicine* 1991; 33(8): 847-852. Meade TW, Dyer S, Browne W, Townsend J, Fran AO. Low back pain of mechanical origin: randomized comparison of chiropractic and hospital outpatient treatment. *British Medical Journal* 1990; 300: 1431-37. **Cervical adjustment:** Canadian Chiropractic Association and the Canadian Federation of Chiropractic Regulatory Boards, Clinical Practice Guidelines Development Initiative, Guidelines Development Committee. Chiropractic Clinical Practice Guidelines: Evidence-Based Treatment of Adult Neck Pain Not Due to Whiplash. *J Can Chiropr Assoc* 2005; 49(3): 158-209. Bronfort G, Evans R, Nelson B, et al. A randomized trial for exercise and spinal manipulation for patients with chronic neck pain. *Spine* 2001; 26: 788-799. Jull G, Trott P, Potter H., et al. A randomized controlled trial of exercise and manipulative therapy for cervicogenic headache. *Spine* 2002; 27: 1835-1843. Hurwitz EL, Carragee EJ, van der Velde G, et al. Treatment of Neck Pain: Noninvasive Interventions. *Spine* 2008; 33: S123-S128. Bronfort G, Haas M, Evans RL, Bouter LM, Efficacy of spinal manipulation and mobilization for low back pain and neck pain a systematic review and best evidence synthesis. *Spine* 2004; 4: 335-356. Gross AR, Goldsmith C, Hoving JL, HainesT, Peloso P, Aker P, Santaguida P, Myers C. Cervical Overview Group - Conservative management of mechanical neck disorders a systematic review. *J Rheumatol* 2007; 34: 1083-1102.

⁵ An article found in the well-respected New England Journal of Medicine illustrates the caution that must be applied to academic reporting on the risk of stroke associated with neck adjustment. The article, "Spontaneous Dissection of the Carotid and Vertebral Arteries" (*NEJM* 2001; 344: 898-906), has been relied on as authority for a comparatively high risk of stroke, based on the following statement: "[i]t has been estimated that as many as 1 in 20,000 spinal manipulations causes a stroke" (p. 900). However, there are two reasons why the cited estimate should be treated with great care.

First, the author of this article, Dr. W.I. Schievink, temporizes the estimate by recognizing that many strokes apparently caused by neck adjustment may actually have been ongoing at the time of treatment (for more on this topic see above at "Questions and Answers about Neck Movement and Stroke" – "How is neck adjustment related to stroke arising from neck movement?"). More importantly, the "1 in 20,000 manipulations" estimate used by Dr. Schievink is unsupported and has been misquoted. The Schevink article indicates the estimate was derived from Vickers A, and Zollman C. ABC of complementary medicine: The manipulative therapies: osteopathy and chiropractic. *BMJ* 1999; 319: 1176-1179. As its title suggests, the Vickers and Zollman article is an introduction to the similarities and differences between osteopathy and chiropractic. The three sentences in the article dealing with the risk of neck adjustment include the following: "[e]stimates for such severe adverse events [including both stroke and spinal cord injury] vary widely, ranging from 1 in 20,000 patients undergoing cervical manipulation to 1 per million procedures" (p. 1178, emphasis added). The authors do not provide a source for either of the estimates comprising this range, so there is no way to evaluate their accuracy. Further, the "1 in 20,000" estimate used by Vickers and Zollman is a measure of adverse events per patient, and therefore, does not support Dr. Schievink's per-manipulation figure. On the basis that most patients will have more than one manipulation in their lifetime, it stands to reason that a comparative per-manipulation estimate should evidence a much lower level of risk.

The CCBC is aware of only one study that reports a risk estimate of approximately 1 in 20,000 patients. In “Stroke following cervical manipulation in Perth” (*Chiropractic Journal of Australia*, 1994; 24: 42-6), chiropractor M.J. Haynes interviewed 17 chiropractors and 7 neurologists in the city of Perth, finding “perhaps fewer than five cases” of apparent stroke following neck adjustment in a patient population of approximately 100,000 (p. 43). Dr. Haynes characterized this estimate of per-patient risk as “extremely low” (p. 45) and equated it to Dr. A.G. Terrett’s then current per-adjustment risk estimate of two to three cases per million neck adjustments (see page two above for Dr. Terrett’s 2001 risk estimate). Dr. Haynes also compared his estimated risk of about 1 stroke per 20,000 patients to estimates of the risk of stroke for young women who take oral contraceptives (13.2 per 100,000) and those who do not (2.8 per 100,000), as well as, a U.S. study that found an incidence of stroke from all causes in the 20 to 33 age group of 394 per 100,000. Based on these comparisons, Dr. Haynes concluded that the role of adjustment in the overall causes of stroke “would probably be negligible” (p. 45).

⁶ See for example, Triano JJ, Kawchuk, G, eds. *Current Concepts in Vertebrobasilar Complications following Spinal Manipulation*. Des Moines, Iowa: National Chiropractic Mutual Insurance Company, 2006, and Hurwitz EL, Aker PD, Adams MH, Meeker WC, Shekelle PG. Manipulation and Mobilization of the Cervical Spine: a systematic review of the literature. *Spine* 1996; 21(15): 1746-1759.

⁷ Terrett AG. *Current Concepts in Vertebrobasilar Complications following Spinal Manipulation*. Des Moines, Iowa: National Chiropractic Mutual Insurance Company, 2001.

⁸ Haldeman S, Carey P, Townsend P, Papadopoulos C. Arterial dissections following cervical manipulation: the chiropractic experience. *Canadian Medical Association Journal* 2001; 165(7): 905-906.

⁹ Hurwitz EL, Aker PD, Adams MH, Meeker WC, Shekelle PG. Manipulation and Mobilization of the Cervical Spine: a systematic review of the literature. *Spine* 1996; 21(15): 1746-1759.

¹⁰ Rothwell DM, Bondy SJ, Williams JI. Chiropractic manipulation and stroke: a population-based, case-controlled study. *Stroke* 2001; 32(5): 1054-1060.

¹¹ National Stroke Foundation: <http://www.strokefoundation.com.au/facts-figures-and-stats>

¹² Heart and Stroke Foundation: www.heartandstroke.bc.ca; Stroke Association (U.K.): www.stroke.org.uk; and American Stroke Association: www.strokeassociation.org.

¹³ Gillium LA, Mamidipudi AK, Johnston, SC. Ischemic Stroke Risk with Oral Contraceptives, a Meta-analysis. *Journal of the American Medical Association* 2000; 284(1). The CCBC recognizes the difficulty in comparing per-treatment and per-patient risk estimates; however, with some health-care interventions, particularly medication, per-treatment risks are meaningless, and so, unavailable.

¹⁴ Tramer MR, Moore RA, Reynolds JM, McQuay HJ. Quantitative Estimation of Rare Adverse Events Which Follow A Biological Progression: A New Model Applied To Chronic NSAID Use. *Pain* 2000; 85: 169-182 (see <http://www.elsevier.nl/locate/pain>).

¹⁵ Rome PL. Perspectives: An Overview of Comparative Considerations of Cerebrovascular Accidents. *Chiropractic Journal of Australia* 1999; 29(3): 87-102.

¹⁶ Dinman BD. The reality and acceptance of risk. *Journal of the American Medical Association* 1980; 233(11): 1226-1228.

¹⁷ Hill MD. Cervical Artery Dissection, Imaging, Trauma and Causal Inference. *Canadian Journal of Neurological Science* 2003; 30(4): 302-304.

¹⁸ See above Rome, “Perspectives: An Overview of Comparative Consideration of Cerebrovascular Accidents”, and Triano and Kawchuk editors, *Current Concepts in Vertebrobasilar Complications following Spinal Manipulation*.

¹⁹ See above Gillium and others “Ischemic Stroke Risk with Oral Contraceptives, a Meta-analysis”.

²⁰ Symons BP, Leonard T, Herzog W. Internal Forces Sustained by the Vertebral Artery During Spinal Manipulative Therapy. *Journal of Manipulative and Physiological Therapeutics* 2002; 25(8): 504-510.

²¹ Wynd S, Anderson T, Kawchuk G. Effect of spinal Manipulation on a Pre-Existing Vascular Lesion within the Canine Vertebral Artery. *Cerebrovascular Diseases* 2008; 26: 304-309.

²² Cassidy D, Boyle E, Côté P, He H, et al. Risk of Vertebrobasilar Stroke and Chiropractic Care: Results of a Population-Based Case-Control and Case-Crossover Study. *Spine* 2008; 33(4S): S176-S183.

²³ Haneline MT, Croft AC, Frishberg BM. Association of Internal Carotid Artery Dissection and Chiropractic Manipulation. *The Neurologist* 2003; 9:35-44.

²⁴ “Health Practitioner Regulation National Law Act 2009” Section 123. <http://www.legislation.qld.gov.au/LEGISLTN/ACTS/2009/09AC045.pdf>

²⁵ Australian Bureau of Statistics. (2004-2005). National Health Survey: Summary of Results. (No. 4364.0). Canberra, Australian Capital Territory.