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Editorial Comment: A Population-Based Case-Control Study

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Chiropractic Manipulation and Stroke
A Population-Based Case-Control Study

Deanna M. Rothwell, MSc; Susan J. Bondy, PhD; J. Ivan Williams, PhD

Background and Purpose—Several reports have linked chiropractic manipulation of the neck to dissection or occlusion of the vertebral artery. However, previous studies linking such strokes to neck manipulation consist primarily of uncontrolled case series. We designed a population-based nested case-control study to test the association.

Methods—Hospitalization records were used to identify vertebrobasilar accidents (VBAs) in Ontario, Canada, during 1993–1998. Each of 582 cases was age and sex matched to 4 controls from the Ontario population with no history of stroke at the event date. Public health insurance billing records were used to document use of chiropractic services before the event date.

Results—Results for those aged <45 years showed VBA cases to be 5 times more likely than controls to have visited a chiropractor within 1 week of the VBA (95% CI from bootstrapping, 1.32 to 43.87). Additionally, in the younger age group, cases were 5 times as likely to have had ≥3 visits with a cervical diagnosis in the month before the case's VBA date (95% CI from bootstrapping, 1.34 to 18.57). No significant associations were found for those aged ≥45 years.

Conclusions—While our analysis is consistent with a positive association in young adults, potential sources of bias are also discussed. The rarity of VBAs makes this association difficult to study despite high volumes of chiropractic treatment. Because of the popularity of spinal manipulation, high-quality research on both its risks and benefits is recommended. **(*Stroke*. 2001;32:1054-1060.)**

Key Words: case-control studies ■ chiropractic ■ complications ■ vertebrobasilar stroke

Recent high-publicity deaths of young adults after chiropractic manipulation have increased public attention toward the safety of chiropractic manipulation of the cervical spine.[1] The apparent association between cervical manipulation and arterial dissection has been reported several times in the literature, with increasing frequency in the last 20 years, coinciding with the rising popularity of chiropractic treatment.

Before the vertebral artery enters the base of the skull and becomes the basilar artery, it changes in direction from a vertical path to a horizontal path, at which point it is susceptible to injury from rotation or extension.[2–5] It has been hypothesized that cervical manipulation may cause dissection or occlusion of the posterior (vertebrobasilar) arteries as they are stretched during the rotation or tilting of the neck.[4–6] Either injury can result in ischemia and brain injury.[4,6–8]

Anecdotally, traumatic vertebrobasilar accidents (VBAs) have mostly occurred in young healthy adults and with a variety of reported causes such as turning the head while driving, coughing, lifting, and sporting injuries, in addition to cervical manipulation.[7] To date, researchers have been unable to identify particular risk factors or precipitating neck movements that result in VBAs,[7,9] and premanipulative testing before neck manipulation has not been shown to be an effective predictor of vertebrobasilar ischemia.[9,10]

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A review of case reports to the end of 1993 found 165 vertebrobasilar complications from spinal manipulation, of which 27% made a full recovery, 52% suffered residual effects, and 18% died as a result.[5] Other case reports and surveys have estimated the risk of VBA after cervical manipulation to be between 1 in 1.3 million to 1 in 400 000 manipulations.[5,9,11,12]

Published reports linking VBAs to therapeutic neck manipulation are predominantly case reports and small case series.[5,11–13] The few observational studies published have also relied on retrospective attribution of causation to a chiropractic visit without objective assessment of exposure in an appropriate control group.[12,13] Even in a recent Canadian stroke study, which has applied a rigorous protocol to the diagnosis of the type of stroke, the persons collecting expo-

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sure data were not blinded to either the diagnosis or outcome.[3]

We sought to examine whether cervical manipulation as practiced in Ontario, Canada, was associated with an increased risk of VBA and to quantify the association using an appropriate case-control design and exposure data extracted from independent administrative records. Since cervical arterial dissection is one of the most common causes of stroke in the young (aged <45 years),[14] we also examined the association separately by age strata.

Subjects and Methods

A population-based nested case-control design was used.[15] Using the date of a case's VBA as the reference date, we created a risk set of all members of the population matching the case on date of birth and sex and simultaneously eligible to be a case as of the reference date. From this risk set, controls were sampled with replacement to create a set of 4 matched controls for each case.[15,16]

Selection of Cases and Controls

All persons admitted to an Ontario acute care facility with a diagnosis of vertebrobasilar dissection or occlusion (*International Classification of Diseases, Ninth Revision* [*ICD-9*] codes 433.0, 433.2, 900.9) over the 6-year period from January 1993 to December 1998 inclusive were selected as potential cases. These *ICD-9* diagnosis codes were chosen in consultation with stroke specialists and medical records administrators. Discharge abstract data for Ontario hospitals were obtained from the Ontario Ministry of Health and Long Term Care. If a person was admitted with a VBA diagnosis more than once during the period, the first hospital admission was used. The date of this admission is the "reference date." Hospitalization records were searched back to April 1988 to exclude patients with previous stroke or VBA (*ICD-9* codes 430 to 438, 900.9). The result was 601 potential cases with no identifiable history of stroke.

Cases were linked by their encrypted health card number to the Ontario Registered Persons Database (RPDB) to obtain sex, birth and death dates, and start and end dates for Ontario Health Insurance Plan (OHIP) eligibility. OHIP is Ontario's universal, publicly financed insurance program. Fourteen cases were excluded who were not OHIP-eligible in the year before the reference date. The remaining cases were linked to the OHIP physician billing database to exclude individuals living in a chronic care facility in the year before their stroke. Patients in chronic care facilities may have had prior strokes treated within the facility without a visit to an acute care center. Five such cases were excluded, leaving 582 cases for matching.

Population-based controls alive at the case reference date were selected from the RPDB. Controls, like cases, were eligible only if they had been eligible for OHIP coverage and not in a chronic care facility during the previous year and had no history of hospital admission for stroke. Matching was used to control for age and sex differences between cases and the general population. With the use of the aforementioned nested case-control approach, 4 matching controls (same sex and birth year) were selected at random, with replacement, from all those simultaneously meeting eligibility criteria at the date of the reference VBA.

Chiropractic Manipulations

Data on chiropractic manipulations were obtained from OHIP billing data for 1992–1998. Chiropractic service billing data were extracted for cases and controls for a period of 1 year before and including the reference date. Multiple billings on the same day were counted as 1 visit. With the use of the diagnostic code attached to each billing, visits were classified as most likely involving cervical manipulation (cervical visit) or not. The following diagnoses were classified as cervical visits: subluxation at cervical, cervicothoracic, thoracic, and multiple sites; cervical and cervicothoracic sprains and strain injuries; cervical and occipital neuritis and neuralgia; cervical radiculitis; and headache.

Statistical Analysis

Conditional logistic regression was used to estimate rate ratios[15] for risk of VBA associated with the timing of the most recent chiropractic visit before the reference date. Similarly, rate ratios were estimated for the risk of VBA associated with the number of chiropractic visits in the year before and in the month before the reference date. Analyses were performed separately for all chiropractic visits and for cervical chiropractic visits alone. CIs were also constructed by nonparametric bootstrap methods.[17] Bootstrapping confidence limits give a better idea of how low event numbers might affect the point estimate had the study been repeated several times. All results were repeated, with stratification by age (age <45 versus age ≥45 years).

Results

Of the 582 cases and 2328 matched controls, 61% were male and 19% were aged <45 years (mean, 60 years; SD, 18.2). The distribution of cases by *ICD-9* diagnosis was as follows: 221 (38%) had occlusion or stenosis of the basilar artery; 283 (49%) had occlusion or stenosis of the vertebral artery; 28 (5%) had occlusion or stenosis of both basilar and vertebral arteries; and 50 (9%) had injury to an unspecified blood vessel of the head and neck.

Overall, 9% of cases and controls had at least 1 chiropractic visit in the year before the reference date (Table 1). Of these, roughly half were visits with a cervical diagnosis. Among those with at least 1 chiropractic visit in the past year, 37% had their most recent visit within 1 month of the reference date. Younger cases had higher chiropractic utilization rates. More than 12% of cases aged <45 years had a chiropractic visit within 1 year, compared with 9% for controls aged <45 years and 9% for both cases and controls aged ≥45 years. Similarly, 8% of cases aged <45 years had a visit with a cervical diagnosis in the previous year, compared with 5% of controls aged <45 years and 4% of cases and controls aged ≥45 years.

Table 1 also shows the numbers of visits for cases and controls in the month before the reference date. The largest differences between cases and controls were observed in those aged <45 years. Cases aged <45 years were 4 times as likely to have had ≥3 visits compared with controls and 5 times as likely to have had ≥3 cervical visits in the previous month.

Conditional logistic regression was used to estimate rate ratios for the risk of VBA (case-control status) associated with the timing and number of chiropractic visits. Table 2 shows the results for all ages. When the timing of chiropractic visits is considered, the rate ratios of the risk of VBA for recent time intervals (within a day or week) were all >1.00; however, none of them reached statistical significance. The rate ratio for having a visit with a cervical diagnosis in the day before the reference date was 3.94 ($P=0.052$); however, the nonparametric bootstrap CI for this point estimate was fairly wide (0.64 to 46.28).

Higher numbers of visits were also associated with higher rate ratios for the risk of VBA; however, the only significant finding was in the analysis of cervical visits, in which the rate ratio associated with ≥3 visits was 3.09 ($P=0.025$). This

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TABLE 1. Timing and Number of Chiropractic Services Before the Reference Date (Date of VBA for Case)

	Entire Cohort		Age <45 y		Age ≥45 y	
	Cases (n=582)	Controls (n=2328)	Cases (n=112)	Controls (n=448)	Cases (n=470)	Controls (n=1880)
Most recent chiropractic visit of any type						
None in past year	525 (90.2)	2118 (91.0)	98 (87.5)	408 (91.1)	427 (90.9)	1710 (91.0)
Within 1 year (31–365 d)	36 (6.2)	131 (5.6)	6 (5.4)	24 (5.4)	30 (6.4)	107 (5.7)
Within 1 month (8–30 d)	9 (1.5)	42 (1.8)	1 (0.9)	10 (2.2)	8 (1.7)	32 (1.7)
Within 1 week (2–7 d)	7 (1.2)	23 (1.0)	5 (4.5)	4 (0.9)	2 (0.4)	19 (1.0)
Within 1 day (0–1 d)	5 (0.9)	14 (0.6)	2 (1.8)	2 (0.4)	3 (0.6)	12 (0.6)
Most recent cervical chiropractic visit						
None in past year	555 (95.4)	2226 (95.6)	103 (92.0)	427 (95.3)	452 (96.2)	1799 (95.7)
Within 1 year (31–365 d)	15 (2.6)	62 (2.7)	3 (2.7)	12 (2.7)	12 (2.6)	50 (2.7)
Within 1 month (8–30 d)	3 (0.5)	21 (0.9)	0 (0.0)	4 (0.9)	3 (0.6)	17 (0.9)
Within 1 week (2–7 d)	5 (0.9)	15 (0.6)	4 (3.6)	4 (0.9)	1 (0.2)	11 (0.6)
Within 1 day (0–1 d)	4 (0.7)	4 (0.2)	2 (1.8)	1 (0.2)	2 (0.4)	3 (0.2)
No. of chiropractic visits of any type in previous month						
None in past month	561 (96.4)	2249 (96.6)	104 (92.9)	432 (96.4)	457 (97.2)	1817 (96.6)
1 visit	7 (1.2)	38 (1.6)	0 (0.0)	8 (1.8)	7 (1.5)	30 (1.6)
2 visits	6 (1.0)	18 (0.8)	3 (2.7)	3 (0.7)	3 (0.6)	15 (0.8)
≥3 visits	8 (1.4)	23 (1.0)	5 (4.5)	5 (1.1)	3 (0.6)	18 (1.0)
No. of cervical chiropractic visits in previous month						
None in past month	570 (97.9)	2288 (98.3)	106 (94.6)	439 (98.0)	464 (98.7)	1849 (98.4)
1 visit	3 (0.5)	22 (1.0)	0 (0.0)	4 (0.9)	3 (0.6)	18 (1.0)
2 visits	2 (0.3)	9 (0.4)	1 (0.9)	1 (0.2)	1 (0.2)	8 (0.4)
≥3 visits	7 (1.2)	9 (0.4)	5 (4.5)	4 (0.9)	2 (0.4)	5 (0.3)

Values are number (%).

measure remained marginally significant after bootstrapping (95% CI from bootstrapping, 0.99 to 12.10). The number of cervical visits was also analyzed as a continuous variable, yielding similar results ($P=0.086$). An analysis of the number of cervical visits within a full year before the reference date showed no increased risk of VBA with increasing numbers of visits when analyzed categorically (likelihood ratio test on 4 *df*, $P=0.952$) or continuously ($P=0.873$).

Table 3 presents the results from the conditional logistic regression analysis stratified by age. For this analysis, some categories were combined because of small numbers. In the group aged ≥45 years, no clear patterns emerged, and there were no significant findings. However, in the group aged <45 years, the rate ratios of the risk of VBA associated with chiropractic within 1 week of the reference date were significant. For chiropractic visits of any type, the rate ratio was 5.03 ($P=0.006$), and for chiropractic visits with a cervical diagnosis, the rate ratio was 5.52 ($P=0.009$). The 95% bootstrap CIs for both point estimates remained significant despite the small underlying cell counts. The rate ratio for the VBA risk associated with ≥3 visits was statistically significant when visits of any type (rate ratio=4.07; $P=0.027$) and cervical visits alone (rate ratio=4.98; $P=0.017$) were analyzed. However, only for cervical visits did the rate ratio remain significant after bootstrapping.

Discussion

The anatomic explanation of how spinal manipulative therapy could cause a stroke is well documented.[3–5,10] However, chiropractic manipulation for head and neck pain remains a very popular treatment choice.[9,18] In Ontario alone there were 10 million chiropractic visits in 1998 for a population of just under 11.5 million (analysis of OHIP claims data). Furthermore, cervical manipulation is not only performed by chiropractors but also by medical practitioners, osteopaths, and physiotherapists, and each profession has documented complications after spinal manipulation.[5,10] Determination of whether and when manipulation of the cervical spine increases the risk of stroke is therefore a matter of some importance.

In this analysis we found an association between recent chiropractic visits and the risk of VBA only in those aged <45 years. The association was present when all visits were analyzed as well as only visits with a cervical diagnosis. In the younger age group, the estimated rate ratio for the risk of VBA associated with a chiropractic visit within 1 week of the reference date was 5.0 for any visits and 5.5 for cervical visits only. An association between the number of visits and the risk of VBA was also found only in those aged <45 years. For them, the estimated rate ratio for the risk of VBA associated with having had ≥3 visits in the previous month was 4.1, while the rate ratio for ≥3 cervical visits was 5.0.

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TABLE 2. Results of Conditional Logistic Regression Models on VBA Cases and Matched Controls, All Ages

Independent Variable (Separate Models)	Odds Ratio	95% CI	
		Model	Bootstrapping
Most recent chiropractic visit of any type			
None in past year	1.0	(Reference)	
Within 1 year (31–365 d)	1.11	0.75–1.63	0.71–1.69
Within 1 month (8–30 d)	0.87	0.42–1.80	0.31–1.67
Within 1 week (2–7 d)	1.23	0.51–2.94	0.40–3.42
Within 1 d (0–1 d)	1.43	0.51–3.96	0.35–4.23
Most recent cervical chiropractic visit			
None in past year	1.0	(Reference)	
Within 1 year (31–365 d)	0.97	0.54–1.72	0.47–1.74
Within 1 month (8–30 d)	0.58	0.17–1.95	0–1.57
Within 1 week (2–7 d)	1.36	0.48–3.85	0.28–4.33
Within 1 d (0–1 d)	3.94	0.99–15.78	0.64–46.28
No. of chiropractic visits of any type in previous month			
None in past month	1.0	(Reference)	
1 visit	0.75	0.33–1.67	0.20–1.54
2 visits	1.35	0.52–3.47	0.29–3.55
≥3 visits	1.39	0.62–3.14	0.51–3.33
No. of cervical chiropractic visits in previous month			
None in past month	1.0	(Reference)	
1 visit	0.55	0.16–1.84	0–1.50
2 visits	0.87	0.18–4.18	0–3.29
≥3 visits	3.09	1.15–8.29	0.99–12.10

VBA is a rare form of stroke. Despite the popularity of chiropractic therapy, the association with stroke is exceedingly difficult to study. Even in this population-based study the small number of events was problematic. Of the 582 VBA cases, only 9 had a cervical manipulation within 1 week of their VBA. Focusing on only those aged <45 reduced our cases by 81%; of these, only 6 had cervical manipulation within 1 week of their VBA.

Because of matching, controls in this study did not have the same age/sex distribution as the population as a whole. Therefore, we estimated the population aged <45 years at risk of VBA by applying age/sex-specific estimates of study eligibility (obtained from our selection of controls) to the midyear populations aged <45 years in RPDB for each study year, where the sum over all years is the population of interest. To this population, we applied an age/sex-standardized estimate of exposure rate to chiropractic within 1 week (from our controls) to estimate the population aged <45 years at risk of VBA and also receiving chiropractic. With the use of these techniques, our analysis indicates that, for every 100 000 persons aged <45 years receiving chiropractic, approximately 1.3 cases of VBA attributable to chiropractic would be observed within 1 week of their manipulation.

Attributable rate estimates indicate that VBAs associated with manipulation are rare, but there is also quite a bit of imprecision in the estimate (95% CI, 0.5 through 16.7 per 100 000). Furthermore, we caution that such rate estimates can easily be overemphasized. Statements about attributable rates imply a causal association and assume that observed relative risk values are unaffected by bias. This study design does not permit us to estimate the number of cases that are truly the result of trauma sustained during manipulation.

To our knowledge this study is the first to examine chiropractic manipulation and stroke using a technique to measure exposure that is completely independent of case definition and identically handled in both cases and appropriately sampled controls. While the observations here are compatible with the argument that there is an increased risk of VBA in young adults from cervical manipulations as performed in clinical practice in this province, they still do not provide conclusive evidence. This use of administrative data afforded one opportunity to study the association objectively, but limitations are noted.

It is possible that the definition of VBA based on selected *ICD-9* codes from hospital records led to an overinclusive or underinclusive cohort of cases. Our definition of cases does not capture nonhospitalized events, subarachnoid hemorrhages secondary to high vertebral artery dissections, or carotid arterial dissections. VBA cases were narrowly defined with the use of selected *ICD-9* codes identified by consulting with stroke experts and a medical records department. Positive validation of the type of stroke would require diagnostic imaging and invasive testing well beyond the scope of the current study. However, according to this definition, a total of 0.42% of all the hospital admissions with a stroke diagnosis in 1993–1998 were classified as having a VBA diagnosis. This number is for dissections and occlusions of the posterior arteries and seems reasonable compared with a published estimate of 1.3 cervical dissections per 1000 strokes.[19] With a mean age of 60 years, our cases are older than those in case reports of traumatic VBA accumulated in a review of case reports in which the mean age was 39 years.[7] While this could indicate a problem with case definition, it is also possible that a publication bias exists in case reports toward more unusual cases.[20]

Completeness of exposure data has also been considered. During the time of this study, the Ontario Health Insurance Plan covered 20 visits per person per fiscal year (approximately $10 per visit). Visits over and above that number would not generally be captured by OHIP. Therefore, it is possible that not all chiropractic visits were captured in this study. However, the number of visits missed is likely small since 77% of the 267 patients who had chiropractic visits had ≤15 visits, and 85% had <20 visits.

Limitations of the chiropractic billing diagnostic code, used to determine whether a chiropractic visit was likely to have involved a cervical adjustment, are noted. This code is used to reflect the general area of the patient's complaint, but application of codes across chiropractic offices is not standardized. It is likely that, by using this code, some visits have been categorized as cervical when in fact no cervical adjustment was performed, and vice versa. This code was used nonetheless as an approximate indicator of which visits entailed manipulation of a sort physiologically relevant to the VBA outcome.

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TABLE 3. Results of Conditional Logistic Regression Models on VBA Cases and Matched Controls, by Age

	Age <45 y			Age ≥45 y		
		95% CI			95% CI	
Independent Variable	Odds Ratio	Model	Bootstrapping	Odds Ratio	Model	Bootstrapping
Most recent chiropractic visit of any type						
None in past year	1.0		(Reference)	1.0	(Reference)	
Within 1 year (31–365 d)	1.00	0.40–2.52	0.25–2.70	1.13	0.74–1.72	0.68–1.79
Within 1 month (8–30 d)	0.48	0.06–3.77	0.00–2.26	1.00	0.46–2.18	0.35–2.23
Within 1 week (0–7 d)	5.03	1.58–16.07	1.32–43.87	0.64	0.25–1.67	0.13–1.56
Most recent cervical chiropractic visit						
None in past year	1.0	(Reference)		1.0	(Reference)	
Within 1 year (31–365 d)	1.05	0.27–3.99	0.00–4.78	0.96	0.50–1.82	0.45–1.82
Within 1 month (8–30 d)	0.00	0.00–infinity	0.00–0.00	0.70	0.20–2.41	0.00–1.95
Within 1 d (0–7 d)	5.52	1.54–19.76	1.03–72.02	0.85	0.24–3.00	0.00–2.95
No. of chiropractic visits of any type in previous month						
None in past month	1.0	(Reference)		1.0	(Reference)	
1–2 visits	1.23	0.33–4.63	0.00–5.25	0.88	0.44–1.77	0.32–1.84
≥3 visits	4.07	1.17–14.12	0.71–29.60	0.66	0.19–2.26	0.00–1.92
No. of cervical chiropractic visits in previous month						
None in past month	1.0	(Reference)		1.0	(Reference)	
1–2 visits	0.88	0.10–7.59	0.00–7.79	0.60	0.21–1.76	0.10–1.47
≥3 visits	4.98	1.34–18.57	1.07–62.70	1.60	0.31–8.25	0.00–10.61

VBAs are rare events with potentially dire consequences. When they occur in otherwise healthy young adults, the natural tendency to seek explanation (recall or rumination bias) may exaggerate the apparent association with use of chiropractic services.[20] The association could also arise from confounding, in which some underlying pathology led to both the VBA and to symptoms such as neck pain for which someone had sought chiropractic care in the first place. In some cases, neck pain is the only sign of a vertebral artery dissection, motivating a person to seek chiropractic treatment. In this case, cervical manipulation could trigger a dramatic brain stem stroke.[21]

These potential sources of bias cannot be addressed without the adoption of a rigorous study protocol. Prospective study of such a rare event could prove extremely difficult and time-consuming, making case-control designs more likely. Thorough diagnostic techniques to confirm the type of stroke, such as those seen in the work of Norris et al,[3] need to be paired with equally rigorous assessment of exposure, including the use of chiropractic services in a properly selected control population and for a comparable time period.[22] Without such studies, a true association, should one exist, cannot be quantified without bias, nor can chiropractors be absolved of causing harm should the association be spurious.

It remains to be explained why an association between chiropractic manipulation and VBA was observed only in the young. If an association were to exist, one would expect that it would exist regardless of age. Dilution of the effect in older age groups is possible where it is more likely that VBA is related to other medical conditions. It could also be the case that, if a predisposition to vertebral artery dissection were to exist, it would show up at an earlier age. On the other hand, chiropractors may perform more aggressive treatment on younger patients.

Even without definitive answers to these questions, caution on the part of the practitioner and patient is justified, and patients should be made aware of the possible risks, however remote. Proper training in the techniques of cervical manipulation and adherence to the professional guidelines already in place are important and designed to prevent injury. However, in the RAND review,[9] complications of spinal cord injury were seen in patients without any predisposing risk factors or positive premanipulative testing. In short, the practitioner cannot reliably assess the risk of central nervous system injury for any particular patient undergoing manipulation. Furthermore, the RAND report stated, “in many cases, the manipulator failed to cease treatment even after signs and symptoms of vertebrobasilar ischemia.”

Ultimately, the acceptable level of risk associated with a therapeutic intervention also must be balanced against evidence of therapeutic efficacy. Therefore, further research is indicated into both the benefits and harms associated with cervical spine manipulation. Practitioners of this technique should be called on to demonstrate the evidenced-based benefit of this procedure and to define the specific indications for which the benefits of intervention outweigh the risk.

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Editorial Comment

Our Canadian colleagues should be congratulated for providing us with some objective data on what has been a highly controversial topic for over 40 years,[1] namely, the relationship between stroke and chiropractic manipulation. For neurologists, there is a little doubt that chiropractic manipulation can cause vertebral artery dissection, with more than 100 reported cases of posterior circulation stroke occurring during or immediately after cervical manipulation. There is also little doubt that this complication is more common than the literature would reflect, an opinion that was already prevalent when J.T. Robertson wrote his editorial in this journal 20 years ago.[2] For chiropractors, by contrast, there is little doubt that there is in the medical literature an overreporting of such cases and a total misunderstanding of what chiropractic techniques involve, the term being applied to any manipulative procedure, whatever the method used.[3]

The present study is the first population-based control study to test the association between chiropractic manipulation and vertebrobasilar dissection or occlusion. Its conclusions are clearcut regarding young subjects (<45 years of age). Those with vertebrobasilar dissection or occlusion were 5 times more likely than controls, first, to have visited a chiropractor in the previous week, and second, to have had 3 or more cervical chiropractic visits in the previous month. It is remarkable that these results were statistically significant despite the small numbers of cases and the use of a conservative statistical method (bootstrapping). This corresponds to an incidence of 1.3 case of vertebral artery dissection or occlusion among 100 000 individuals receiving chiropractic manipulation. This is far more than the 1 case per million generally believed.[4] In older populations, no association was found.

Despite these significant results, the authors are extremely cautious in their conclusion, stressing the fact that the demonstration of this association "still does not provide conclusive evidence." They rightly emphasize the many potential biases existing in their study, and they make a plea for "further research into both the benefits and harms associated with cervical spine manipulation." All will agree with this statement, but it is clear that no such research will be successfully performed without a close collaboration between medical doctors and chiropractors: medical doctors by clarifying the role of possible risk factors such as hypertension, smoking, oral contraceptives, migraine, elastic tissue diseases, fibromuscular dysplasia, and congenital cervical spine abnormalities, and chiropractors by better defining the specific techniques used and by scientifically assessing the overall balance of risks and benefits of the procedure.

In the meantime, chiropractic cervical manipulation cannot be considered risk free, particularly in view of the fact that, as mentioned by the authors, vertebral artery dissection can present with neck pain as the only symptom, thus leading the patient to consult a chiropractor. Although the limitation of neck movements is less marked in vertebral artery dissection than in torticollis,[5] these 2 conditions may be indistinguishable, leading to dramatic consequences if a cervical manipulation is performed on an already-dissected artery.[6] Should the suspicion of dissection be raised, the appropriate ultrasound and MR angiography techniques (and conventional angiography, if the diagnosis remains unclear) should be performed immediately.

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