Research Paper Review

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Internal carotid artery strains during high-speed, low-amplitude spinal manipulations of the neck

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Reviewed by Dr. Jeff Muir DC (Research Review Service)

ABSTRACT

Objective

The primary objective of this study was to quantify the strains applied to the internal carotid artery (ICA) during neck spinal manipulative treatments and range of motion (ROM)/diagnostic testing of the head and neck.

Methods

Strains of the ICA (n = 12) were measured in 6 fresh, unembalmed cadaveric specimens using sonomicrometry. Peak and average strains of the ICA obtained during cervical spinal manipulations given by experienced doctors of chiropractic were compared with the corresponding strains obtained during ROM and diagnostic testing of the head and neck.

Results

Peak and average strains of the ICA for cervical spinal manipulative treatments were significantly smaller ($P < .001$) than the corresponding strains obtained for the ROM and diagnostic testing. All strains during ROM and treatment testing were dramatically smaller than the initial failure strains of the ICA.

Conclusions

This study showed that maximal ICA strains imparted by cervical spinal manipulative treatments were well within the normal ROM. Chiropractic manipulation of the neck did not cause strains to the ICA in excess of those experienced during normal everyday movements. Therefore, cervical spinal manipulative therapy as performed by the trained clinicians in this study, did not appear to place undue strain on the ICA and thus does not seem to be a factor in ICA injuries.

ANALYSIS

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Background Information
Spinal manipulative therapy (SMT) is a widely utilized modality to treat back and neck problems, including mechanical neck pain and headaches (1-4). Although the peak forces exerted during SMT vary dramatically between clinicians and depend strongly on the area of application, thrust times remain consistent, within approximately 100 milliseconds among clinicians and a variety of high-velocity techniques.

While the force used in cervical SMT is a fraction of that used in the thoracic or lumbar regions, there is nonetheless concern regarding the possibility of damaging internal structures at the treatment site during this procedure. One of the major areas of concern regarding patient safety is that of SMT of the neck and the risk of stroke. Although very rare and virtually impossible to accurately quantify – estimates of approximately 1 in 1 million treatments have been proposed by a recent systematic review (1) – the severity and irreversibility of this particular adverse effect represent a significant risk and therefore make forces incurred during cervical SMT worthy of investigation.

The majority of concern regarding adverse incidents associated with cervical SMT involves the vertebral artery, although the internal carotid artery (ICA) has recently been proposed as another site of potential injury (5, 6). With little or no information available regarding the mechanics of the internal carotid artery during SMT, the purpose of this study was to determine the nature of internal carotid biomechanics and associated risk of injury during cervical SMT.

PERTINENT RESULTS
The primary result of this study is that the maximal strain in the ICA occurred during ROM testing and was significantly ($p < 0.001$) greater than the corresponding maximal strains observed during SMT. This finding was observed individually for each clinician and each ICA tested in this study, showing good inter-subject and inter-clinician consistency. These results demonstrate that stretching of the ICA during high-speed, low-amplitude spinal manipulations of the neck is considerably smaller than the stretching of the ICA that occurs when moving the head and neck to the end ROM. The mean values (mean values calculated across all SMTs and all ROM tests, respectively) of ICA strains were also significantly ($p < 0.001$) smaller for the SMT (2% ± 4%) than the ROM testing (7% ± 9%).

The authors attempted to address the possible extrapolation of these findings to live patients. In this regard, one important aspect considered was the force applied by the clinician during cervical SMT. The authors found that, when asked to give the same neck SMT as used in this study to a series of patients in a clinical setting, clinicians tended to apply similar forces to two sets of live populations (patients and non-patients), whereas the forces exerted on the cadavers differed substantially from those given to the live subjects. Specifically, the force associated with SMT in cadavers was significantly more than that applied to live subjects. The authors suggest that this finding should help to alleviate any concerns that the forces used in this study were not sufficient to mimic those applied to a lives patient in a clinical setting.

CLINICAL APPLICATION & CONCLUSIONS

The findings of this study indicate there is less strain applied to the internal carotid artery during cervical SMT than during normal range of motion movements (remember, this study did not investigate forces on the vertebral artery). While this finding is encouraging and should provide some evidence to contradict the suggestions that cervical SMT is inherently dangerous, clinicians need to continue to take great care to screen for possible risk factors and contraindications to cervical SMT, due largely to the severe and irreversible adverse effects that can be associated with this potential adverse reaction to its application.

STUDY METHODS

Subjects

Testing was performed on 8 fresh (< 72 hours post-mortem), un-embalmed human cadaveric specimens (a total of 15 ICAs).

ICA Dissection

The ICA was approached by blunt dissection using an anterolateral approach. This procedure was similar to that used previously by these authors in their investigation on the effects of cervical SMT on the vertebral artery (7). Care was taken to leave all structures intact while exposing the ICA. Specifically, no ligaments, muscles, or bones were cut to preserve the in situ mechanical behavior of the ICA.

Range of Motion Testing and Spinal Manipulative Treatments

Range of motion testing was performed in flexion, extension, rotation, and lateral bending. Cervical SMT was performed as follows:

1. a diversified lateral/rotary manipulation with a second metacarpal contact specifically against the articular pillar with the cadaver supine; and
2. a pure lateral manipulation with the force applied in a lateral direction to the neck

SMT was delivered at levels C1/C2, C3/C4, and C6/C7 while measuring strains in the ICAs bilaterally. All ROM testing was repeated 3 times and bilaterally; all SMTs were repeated 3 times, on all levels and both sides of the neck. All ROM and SMT testing was performed by 2, 3, or 4 licensed chiropractors per cadaver.

ICA Strain Measurements

Strain measurements were made using sonomicrometry. Two sonomicrometry crystals of 1.0-mm diameter were inserted into the wall of the ICA at its straight portion in the area between C1 and C7. Crystals were placed in the lumen of the artery and then sutured to the ICA wall so that they could not move relative to the ICA itself. Each crystal served as a receiver and a transmitter of short (400 ns) ultrasound pulses. Knowing the time required for traveling from one crystal to the next with the head and neck in the neutral position, strains during ROM and SMT testing were calculated by the increase or decrease in time it took to cover the distance from one crystal (transmitter) to its neighboring crystal (receiver).

ICA Failure Strain Measurements

Following all SMT and ROM testing, the ICAs were carefully dissected and placed in physiologic saline with the sonomicrometry crystals left intact in the arterial walls. The ICAs were then placed in a materials testing machine, set at the neutral strain length (determined from the sonomicrometry

crystals), and then stretched to failure at a speed of 60% strain/s. Strains were measured continuously during the stretching protocol, and failure was defined as the first appearance of a negative slope on the force-elongation plot.

STUDY STRENGTHS / WEAKNESSES

Limitations

Substantial slack existed in the internal carotid arteries – that is, the ICA was far from straight in the neutral head and neck position. Thus, the neutral length often changed substantially in these specimens as "neutral" length could not be uniquely defined in slack ICAs. As a result, measurements were made from the neutral position for each individual test subject.

All experiments were performed on cadaveric specimens, which might logically affect the interpretation and extrapolation of the results. ICAs were also inflated using ultrasound gel, which may alter their biomechanical properties.

The cadavers were relatively old and thus might not represent the normal target population who receives neck SMT. However, one would reasonably expect that the increased age, the implantation of the sonomicrometry crystals, the dissection procedures, and the removal of the artery would have compromised the integrity and thus caused failure at smaller strains than one would expect from a normal, intact ICA in a young individual. Therefore, the authors believe that the mean failure strain observed here is, in fact, a low estimate of the true failure strains of intact ICAs in living people.

Strengths

Great care was taken to ensure that the ICAs were not altered, nor were the surrounding structures, in preparation for the study.

The authors satisfactorily addressed and accounted for the limitations in the study.

The importance of the study is significant, given the fear and 'stigma' attached to this treatment, which, in some patients and patient-advocacy groups, outweighs the clinical benefit.

Additional References

1. Hurwitz EL, Aker PD, Adams AH et al. Manipulation and mobilization of the cervical spine. A systematic review of the literature. Spine 1996; 21: 1746-59.
2. Haldeman S, Kohlbeck DC, McGregor M. Unpredictability of cerebrovascular ischemia associated with cervical spine manipulation therapy. Spine 2002; 27: 49-55.
3. Herzog W. Clinical biomechanics of spinal manipulation. Philadelphia: Churchill Livingstone; 2000.
4. Bronfort G, Assendelft WJ, Evans R et al, Efficacy of spinal manipulation for chronic headache: a systematic review. J Manipulative Physiol Ther 2001; 24: 457-66.
5. Peters M, Bohl J, Thomke F et al. Dissection of the internal carotid artery after chiropractic manipulation of the neck. Neurology 1995; 45: 2284-6.

6. Parwar BL, Fawzi AA, Arnold AC, Schwartz SD. Horner's syndrome and dissection of the internal carotid artery after chiropractic manipulation of the neck. Am J Ophthalmol 2001; 131: 523-4.
7. Symons B, Leonard TR, Herzog W. Internal forces sustained by the vertebral artery during spinal manipulative therapy. J Manipulative Physiol Ther 2002; 25: 504-10.

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