Uniaxial Tensile Properties of Atherosclerotic Carotid Artery After Mobilization of Pushing on Qiao-Gong: A Safety Study Using an Animal Model of Carotid Atherosclerosis

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Abstract

Objectives: This study aimed to preliminarily explore the effects of the soft tissue mobilization of pushing on Qiao-Gong (MPQ) on biomechanical properties of the carotid artery using an animal model of carotid atherosclerosis (CAS).

Methods: Fifty rabbits were randomly divided into 4 groups: animals with CAS treated with MPQ (CAS-MPQ [n = 15]); animals with CAS treated without MPQ (CAS [n = 15]); normal animals treated with MPQ (normal-MPQ [n = 10]); and a blank control group (n = 10). The MPQ procedure consisted of soft tissue mobilization of the Qiao-Gong acupoint on the front edge of the sternocleidomastoid muscle applied from top to bottom, by flat pushing with the thumb repeatedly for 20 times. Disease in the CAS models was induced by carotid artery balloon injury combined with a high-fat diet for 12 weeks. At the end of modeling, carotid color Doppler ultrasonography examination was performed to confirm which animal models were successfully induced with CAS, excluding model rabbits without typical CAS at the same time. Then, MPQ was applied on rabbits in the CAS-MPQ and the normal-MPQ groups for 3 weeks. By contrast, rabbits in the other 2 groups were fed normally without MPQ. Uniaxial failure tests were later performed on carotid arteries in all 4 groups, and at the end of the study, a 2-way factorial analysis of variance of the results was conducted.

Results: (1) At the end of modeling, 10 rabbits in the CAS-MPQ group and 9 in the CAS group were included with typical carotid atherosclerotic characteristics. (2) Young's elastic modulus of the rabbit carotid artery increased more significantly in the CAS-MPQ group than the CAS group. (3) Compared with normal rabbit carotid arteries, atherosclerotic carotid arteries had lower levels of ultimate stress and ultimate strain but higher levels of ultimate load.

Conclusions: The uniaxial tensile mechanical properties of the rabbit atherosclerotic carotid artery were impaired after MPQ. (J Manipulative Physiol Ther 2018;41:164-173)

Key Indexing Terms: *Massage; Medicine, Chinese Traditional; Carotid Arteries; Atherosclerosis*

Introduction

Manual therapy has been applied worldwide to relieve the symptoms of biomechanical dysfunction.[1-3] Manual therapy to the neck is common in the treatment of cervical musculoskeletal pain or dysfunction, which includes application of accurately determined and specifically directed manual force to the neck.[4-6] Anatomic structures in the neck are both important and vulnerable because the cervical spine is weaker than other spinal areas, as a result of its lower stability and proximity to important neural and vascular structures.[7] As a result, there are concerns about various forms of care that involve inputting force to the neck.

The complications after cervical manipulation have been rarely reported,[8-11] but there is a concern for underreporting

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because certain complications such as artery dissections could remain silent for days or weeks. Soft tissue mobilization or massage may sometimes cause bruising, soreness, and arterial injury.[11-13] Manipulation has aroused concern about safety with its popularity.[14] However, compared with manipulation, little is known about the side effects of soft tissue mobilization or message.

With regard to the adverse effects on cervical artery, previous studies have mainly focused on the vertebral artery (VA), and almost no studies have focused on the carotid artery (CA).[15-18] The CA is in a more superficial anatomic location compared with the VA, as indicated by the CA pulse being easily felt on both sides of the neck under the jaw. Therefore, a certain manual therapy may be more likely to affect the CA rather than the VA. For instance, in traditional Chinese medicine (TCM), the soft tissue mobilization of pushing on Qiao-Gong (MPQ) is one of the common cervical manual therapies, contributing to the relief of cervical muscle strains, neck pain, tension headaches, hypertension, and dizziness. The MPQ uses a repetitive force of flat pushing and pressing on the linear acupoint of Qiao-Gong from top to bottom. The acupoint of Qiao-Gong is located at the front edge of the sternocleidomastoid muscle, approximately along the superficial projection of the CA.[19,20] It is unclear what adverse effects the repetitive and direct force of MPQ would have on the CA during the procedure.

As one of the major arteries, the CA supplies the blood of the brain and face, and it is vulnerable because of its special anatomic position relative to the neck. It is a common site for atherosclerosis as well. Carotid atherosclerosis (CAS) indicates degradation of the collagen structure, thickening of the intima, and formation of complex plaques that contain regions with a lipid-rich necrotic core, calcifications, and often intraplaque hemorrhage.[21,22] Carotid atherosclerosis also may be one of the potential risk factors contributing to ischemic stroke (IS), possibly because of the occurrence of CA stenosis, unstable plaque, and even rupture.[23-25] This raises the question of whether CAS should be considered a potential contraindication of MPQ. It is uncertain if patients with CAS may be susceptible to IS or other arterial complications if they underwent MPQ therapy.[1,26-28] In addition, related studies mainly explored the effects on vascular hemodynamic properties[29,30] but did not explore the effects on vascular biomechanical properties. It has also been reported that the biomechanical properties of the arterial wall could be closely linked to the risk of the rupture of atherosclerotic plaque.[31,32] Knowing the variations in vascular biomechanical properties would be helpful in determining the risk of cerebrovascular accidents.

Because of this knowledge gap, we tested the hypothesis that MPQ may impair the biomechanical properties of the atherosclerotic CA, which may be one of the risks leading to the occurrence of adverse events. Therefore, the purpose of this study was to preliminarily explore the potential adverse effects of MPQ on the CA by applying it on the rabbit models of CAS, along with some unidirectional failure tests.

Methods

Animals

All procedures were approved by the Institutional Animal Care and Use Committee of China Academy of Chinese Medicine Science (No. 201506034). Fifty healthy male purebred New Zealand white rabbits aged 3 months (weight range: 2.0-2.4 kg) were housed in a pathogen-free facility in microisolator cages (China Academy of Chinese Medicine Science Experimental Animal Center, Beijing, China). All animal care was done in accordance with the "Guide for the Care and Use of Laboratory Animals" (Office of Science and Health Reports CPRR/NIH 1996).

All rabbits were randomly divided into 4 groups: animals with CAS treated with MPQ (CAS-MPQ [n = 15]); animals with CAS treated without MPQ (CAS [n = 15]); normal animals treated with MPQ (normal-MPQ [n = 10]); and a blank control group (n = 10).

Atherosclerosis Modeling

In the CAS-MPQ group and the CAS group, the atherosclerosis model was induced by CA balloon injury combined with a high-fat diet (1% cholesterol, 5% lard, 7.5% egg yolk, 86.5% common feed; Beijing Jin Muyang Experimental Animal Feed Science and Technology, Beijing, Beijing City, China). The model rabbits were fed with the high-fat diet (120 g/d) after adapting to the environment for 1 week; then, the model rabbits were anesthetized with 3% pentobarbital sodium (22.5 mg/kg intravenously [IV]), followed by balloon injury procedures on the left common CA in accordance with the previously described method.[33,34] The 3.0-mm balloon catheter was gently inflated and retracted, and it was pushed and pulled 3 times inside the left common CA of each model rabbit. A postoperative muscular injection of ampicillin (50 mg/kg/d for 5 days) was given to the subjects to prevent infection. The high-fat diet continued for 12 weeks after the surgery. During the entire experiment, the normal rabbits in the normal-MPQ group and the blank control group were fed a regular diet (120 g/d) for the same time. All rabbits were given free access to water.

Ultrasonography Examination

As a noninvasive technique, ultrasonography examination was carried out on all rabbits to detect the presence of atherosclerosis at the 12th week after modeling, in accordance with the previously described method.[35] For preparation, the rabbits were lightly anesthetized with 3% pentobarbital sodium (20 mg/kg IV) and fixed in the dorsal position with shaved neck skin. Warm ultrasound