Effects of Tuiqiao Gong Manipulation on Hemodynamics in a Cynomolgus Monkey Model of Mild Carotid Atherosclerosis: Postprint

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Abstract

Objective: To investigate the effects of Tui Qiaogong manipulation on hemodynamics in a cynomolgus monkey model of mild carotid atherosclerosis.

Methods: Nine healthy cynomolgus monkeys were randomly divided into three groups (n=3 per group): Tui Qiaogong group, model control group, and blank control group. Mild carotid atherosclerosis models were established in monkeys of the Tui Qiaogong and model control groups, after which the Tui Qiaogong group received the corresponding manipulation intervention. Finally, carotid vascular status and hemodynamics were comparatively evaluated across the three groups.

Results: (1) Color Doppler ultrasound examination revealed plaque formation in both the Tui Qiaogong and model control groups. Compared with the blank control group, the Tui Qiaogong and model control groups showed statistically significant differences in vascular cross-sectional area, plaque cross-sectional area, and plaque stenosis rate ($P<0.05$), while no statistically significant difference was observed between the Tui Qiaogong and model control groups ($P>0.05$). (2) In various hemodynamic parameters, compared with the blank control group, the Tui Qiaogong and model control groups exhibited statistically significant differences ($P<0.05$), whereas no statistically significant difference was found between the Tui Qiaogong and model control groups ($P>0.05$).

Conclusion: Atherosclerotic plaques affect carotid hemodynamics; however, Tui Qiaogong manipulation does not influence plaque stability in the short term, nor does it aggravate hemodynamic effects.

Full Text

Preamble

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Abstract

Objective To investigate the hemodynamic effects of pushing manipulation on the Qiaogong acupoint in cynomolgus monkeys with mild carotid atherosclerotic plaques. **Methods** Nine healthy cynomolgus monkeys were randomly divided into three groups (n=3 each): pushing manipulation group, model control group, and blank control group. Mild carotid atherosclerosis models were established in the pushing manipulation and model control groups, after which the pushing manipulation group received the corresponding manual intervention. Carotid artery morphology and hemodynamic parameters were then compared across the three groups. **Results** (1) Color Doppler ultrasound examination revealed plaque formation in both the pushing manipulation and model control groups. Compared with the blank control group, significant differences were observed in vascular cross-sectional area, plaque cross-sectional area, and plaque stenosis rate ($P<0.05$), while no significant differences were found between the pushing manipulation and model control groups ($P>0.05$). (2) For hemodynamic parameters, significant differences were noted in the pushing manipulation and model control groups compared with the blank control group ($P<0.05$), but no significant differences existed between the two intervention groups ($P>0.05$). **Conclusion** While atherosclerotic plaques affect carotid hemodynamics, pushing manipulation on the Qiaogong acupoint does not compromise plaque stability or exacerbate hemodynamic disturbances in the short term.

Keywords: pushing manipulation; Qiaogong acupoint; carotid atherosclerosis; plaque; hemodynamics

Introduction

Hypertension represents one of the most prevalent chronic diseases worldwide. Atherosclerosis (AS) is a chronic inflammatory condition and a critical intermediate link in target organ damage caused by hypertension. AS constitutes an abnormal vascular response to various injuries, often presenting without specific symptoms until related organs become compromised. Among various forms of AS, carotid atherosclerosis (CAS) is particularly common and serves as the pathological basis for acute cardiovascular and cerebrovascular events such as

myocardial infarction and ischemic stroke. Recent data indicate that approximately 60–80% of stroke subtypes in China are ischemic strokes, with CAS accounting for about 20% of these cases. Modern medical management of hypertension relies primarily on pharmacological control, which, while effective, carries certain side effects. Patients with hypertension complicated by CAS require particularly careful selection of antihypertensive medications. Although traditional Chinese medicine does not explicitly mention CAS, most scholars consider it to fall within the categories of "blood stasis" and "phlegm turbidity."Common therapeutic approaches include herbal compound formulations and herbal extracts. However, since pharmacological treatment for CAS-related hypertension typically continues throughout life, exploring non-pharmacological therapies holds significant importance for disease prevention and management.

Clinical studies have demonstrated that tuina therapy is an effective method for preventing and treating hypertension, with pushing manipulation on the Qiaogong acupoint being particularly notable. References to the Qiaogong acupoint can be traced back to the *Huangdi Neijing* period, though its specific manipulation techniques were developed in modern times. The Qiaogong acupoint represents an important tuina point summarized from folk medical experience and has been adapted for hypertension treatment in contemporary practice. Despite its significant antihypertensive efficacy, pushing manipulation may be associated with complications such as cerebrovascular accidents. Improper application of manual techniques—such as unstandardized procedures or excessive force—can alter the biomechanical properties of CAS plaques, potentially leading to plaque rupture and subsequent acute cardiovascular or cerebrovascular events. Research indicates that hemodynamic changes in the carotid artery constitute a key factor in CAS plaque rupture. For instance, alterations in local hemodynamics may transform laminar flow into turbulent flow, increasing wall impact forces and generating substantial shear stress, thereby compromising plaque stability and causing detachment or rupture. Therefore, evaluating the hemodynamic effects of pushing manipulation on CAS plaques is crucial for enhancing the safety of this technique.

While clinical studies have affirmed the therapeutic effects of pushing manipulation on the Qiaogong acupoint, whether the manipulation process affects plaque stability, alters hemodynamics, or exacerbates CAS to cause plaque detachment and life-threatening complications remains undefined, with few relevant studies reported. Consequently, this investigation into the hemodynamic effects of pushing manipulation intervention in a CAS model holds considerable clinical significance.

Materials and Methods

1.1 Reagents, Consumables, and Instruments

Zoletil 50 anesthetic was purchased from Virbac (France). Iodophor, sterile instrument kits, and tourniquets were obtained from Beijing Zhongshan Golden

Bridge Company. High-fat diet (containing 2% cholesterol, 10% lard, and 88% standard chow) was prepared by Yunnan Yingmao Company. The color Doppler ultrasound diagnostic system was from Philips (Netherlands; model: L15-7io).

1.2 Experimental Animals and Grouping

Nine healthy male cynomolgus monkeys (specific-pathogen-free grade), weighing 6–7 kg and aged 4–5 years, were housed and experimented on at the Yunnan Yingmao Experimental Center (Animal License No. SYXK (Dian) 2009-0003). All procedures were approved by the center' s Animal Experimental Ethics Committee. The monkeys were randomly divided into three groups (n=3 each): pushing manipulation group, model control group, and blank control group. Grouping preceded model establishment; pushing manipulation and model control groups underwent CAS modeling, while the blank group received no intervention.

1.3 Model Establishment

Mild CAS models were created in the pushing manipulation and model control groups, with only one common carotid artery modeled per monkey. After anesthesia with Zoletil 50 (5 mg/kg), standard disinfection and draping were performed. The common carotid artery was isolated between the sternocleidomastoid muscle and thyroid cartilage. A syringe needle was inserted into the artery and repeatedly scraped against the intimal wall. Following needle removal, the puncture site was compressed with gauze until bleeding ceased. The wound was irrigated and closed in layers. All surgeries were performed by the same operative team. Postoperative wound condition and swallowing/feeding behavior were monitored. For three days post-surgery, levofloxacin hydrochloride and sodium chloride injection (8 mg/kg) was administered intravenously for infection prophylaxis, and tramadol hydrochloride injection (2 mg/kg) was given intramuscularly for pain management. High-fat feeding commenced immediately after surgery. At eight weeks post-surgery, color Doppler ultrasound under anesthesia confirmed CAS plaque formation on the common carotid artery intima [Figure 1: see original paper]. The model plaque stenosis rate was (7.28±0.82)%, classified as mild stenosis according to 2003 North American Radiological Society ultrasound criteria. Specifically, the pushing manipulation group showed a stenosis rate of (7.35±0.98)%, while the model control group showed (7.22±0.85)%, with no significant between-group difference ($P>0.05$), confirming comparability.

1.4 Manual Intervention

Following successful modeling, monkeys in the pushing manipulation group were secured in a fixation chair and received 20 manipulations along each carotid artery once daily for 30 days. The model control and blank groups received no special intervention. All manual procedures were performed by a single attending physician.

1.5 Examination Methods

Under anesthesia with Zoletil 50 (5 mg/kg), monkeys were placed in supine position with slight neck extension for adequate exposure. Ultrasound probe examination was performed at 1.37±0.10 cm from the carotid bifurcation, assessing common carotid artery morphology and plaques. Parameters included vascular cross-sectional area, plaque cross-sectional area, and plaque stenosis rate (plaque area/vascular area × 100%). Hemodynamic parameters comprised peak systolic velocity (PSV), end-diastolic velocity (EDV), time-averaged velocity (TAV), resistive index (RI) [(PSV-EDV)/PSV], and pulsatility index (PI) [(PSV-EDV)/TAV].

1.6 Statistical Methods

SPSS 20.0 software was used for statistical analysis. Measurement data are expressed as mean ± standard deviation. Inter-group comparisons were performed using one-way ANOVA (LSD-t test) with =0.05. P<0.05 was considered statistically significant.

Results

Color Doppler ultrasound examination revealed plaque formation in both the pushing manipulation and model control groups. Compared with the blank control group, significant differences were observed in vascular cross-sectional area, plaque cross-sectional area, and plaque stenosis rate (P<0.05), while no significant differences existed between the pushing manipulation and model control groups (P>0.05) [FIGURE:2, 3]. For hemodynamic parameters (PSV, EDV, TAV, RI, PI), significant differences were noted in the pushing manipulation and model control groups compared with the blank control group (P<0.05), but no significant differences were found between the two intervention groups (P>0.05) [FIGURE:4, 5].

Discussion

Carotid atherosclerotic plaques represent intimal surface protrusions, with intimal thickening being an early sign of CAS and atheromatous plaque formation constituting its most characteristic lesion. We therefore employed a CAS modeling method combining needle scratching with high-fat feeding, which successfully produced visible plaques on the common carotid artery intima at eight weeks post-surgery. The model plaque stenosis rate of (7.28±0.82)% confirmed mild stenosis. No animal mortality occurred during modeling, demonstrating the safety and efficacy of this approach for establishing mild CAS models and providing a solid foundation for subsequent experiments.

Plaque rupture is a complex process resulting from multiple factors: (1) Hemodynamic factors—local low wall shear stress and high oscillatory shear index

represent high-risk factors for plaque formation and rupture. (2) Plaque vulnerability—plaque morphology, size, composition, and biological activity are closely related to stability. Vulnerability correlates negatively with fibrous cap thickness but positively with inflammatory cell count and lipid core size. Macrophage density within plaques is a critical determinant of stability, with higher macrophage counts indicating greater instability. Additionally, hemodynamics correlates with plaque vulnerability. (3) Mechanical stress—improper cervical manipulation, excessive force, or violation of anatomical principles may damage carotid arteries, tear nerve fibers, and subject AS plaques to high stress, causing detachment or rupture and leading to acute cerebrovascular events.

Numerous tuina texts and clinical experiments have demonstrated that pushing manipulation on the Qiaogong acupoint produces excellent immediate blood pressure-lowering effects with benign, bidirectional regulation and no toxic side effects. Abnormal hemodynamics promotes CAS formation and progression, making investigation of this manipulation' s hemodynamic effects in cynomolgus monkeys with mild CAS plaques clinically significant.

In this study, the pushing manipulation and model control groups showed significant differences from the blank control group in common carotid artery cross-sectional area, plaque cross-sectional area, and plaque stenosis rate ($P<0.05$), but no significant differences between the two intervention groups ($P>0.05$), indicating plaque formation in both groups and confirming that short-term pushing manipulation does not affect plaque stability. For hemodynamic parameters, PSV, EDV, and TAV were lower in the intervention groups than in the blank control group, demonstrating that plaque formation affects carotid blood flow velocity and consequently impairs perfusion. Meanwhile, RI and PI were higher than normal ($P<0.05$), indicating increased vascular wall load in CAS. However, no significant differences in PSV, EDV, TAV, RI, or PI existed between the pushing manipulation and model control groups ($P>0.05$), suggesting that short-term pushing manipulation does not exacerbate hemodynamic disturbances.

This study has several limitations: (1) It focused exclusively on mild CAS, leaving moderate and severe CAS for future investigation. (2) For ethical and safety considerations, cynomolgus monkeys rather than humans served as experimental subjects; whether manual effects differ between species requires further study.

In summary, atherosclerotic plaques affect carotid hemodynamics, but pushing manipulation on the Qiaogong acupoint does not compromise plaque stability or worsen hemodynamic disturbances in the short term.

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