High-tech acupuncture® made in Austria — cerebral circulation

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ABSTRACT: It is little known that Austria has tradition in research in Chinese integrative medicine, especially traditional Chinese medicine. For more than 15 years, the research concerning high-tech acupuncture has been playing an important role at the Medical University of Graz, Austria. Within this review article, a short summary concerning high-tech acupuncture and cerebral circulation, and transcranial Doppler (TCD) sonography is presented. TCD has been extensively used in various basic and clinical situations, and in the last decade has established its role also as a tool of investigating the effects of various acupuncture methods. Based on the Doppler principle, it uses ultrasound waves to insonate the blood vessels supplying the brain and to obtain stimulation-induced changes of hemodynamic information. The purpose of this review is to present the basic concepts of TCD technique in relation to acupuncture research, and the specific effects on cerebral hemodynamics caused by acupuncture stimulation.

KEYWORDS: laser acupuncture; Austria; cerebrovascular circulation; ultrasonography; blood flow velocity; laser-doppler flowmetry; review

The Medical University of Graz is located in the capital of the province of Styria, Austria, which is also called “Austria’s green heart”. Compared to universities in China, our university is very small. However, we had four Nobel prize winners in the past. In general, Austria is probably known in China for its culture, especially the music, and the success of its skiers. What is less known is the fact that the diplomatic ties between China and Austria could reach back to 1971; this means more than 40 years. China became Austria’s largest trade partner outside of the European Union. But the bilateral relations are not based on economy alone; Austria also has some tradition in research in Chinese integrative medicine, especially traditional Chinese medicine (TCM). For more than 15 years, the research concerning high-tech acupuncture has been playing an important
role at our university in Graz. Over the last few years, we have built up a high-tech acupuncture network with many important partners from China. Apart from the China Academy of Chinese Medical Sciences, there are cooperations within this network with Heilongjiang University of Chinese Medicine, Capital Medical University, Beijing University of Chinese Medicine, Beijing University of Science and Technology, Fudan University, and Chengdu University of TCM.

Investigations using sophisticated biomedical technology are one way to understand how acupuncture works. Scientific studies have shown that the key to understanding the mechanism of acupuncture lies in the brain. Multifunctional high-tech monitoring equipment developed in Graz can reproducibly and objectively demonstrate and measure the effects of needle and laser stimulation in the periphery and in the brain\(^{[3-12]}\). This short review article summarizes some important aspects concerning cerebral circulation, acupuncture stimulation, and ultrasound from the last years\(^{[4]}\). All measurements were performed in the high-tech acupuncture lab in Graz. Our competence center at the Medical University of Graz is interested in basic research and those aspects of TCM that have not been given much attention so far, for example, the quantification of new acupuncture techniques such as laser acupuncture and electroacupuncture. Possible effects of acupuncture in combination with other methods are also subject to scientific research. For further information, see http://litscher.info.

1 Ultrasound for acupuncture research

Ultrasound waves are mechanic, matter-bound density waves with frequencies of more than 20 kHz. They are produced by applying electric alternating voltage to piezoelectric crystals (transducer). The waves propagate in biologic tissue (with the exception of bone) at a nearly constant speed (\(\sim 1,550\) m/s). The waves are totally or partially reflected and weakened by scattering and absorption at biologic-acoustic border regions. Ultrasound waves of low intensity (\(< 10\) mW/cm\(^2\); diagnostics) are considered to be harmless\(^{[4]}\). It has to be mentioned that higher intensities may pose a danger, especially when insonating the eye\(^{[4]}\).

Investigations of the neuronal correlates of acupuncture in the human brain were limited by the lack of non-invasive continuous measurement methods such as multidirectional transcranial Doppler (TCD) sonography in the past. In different studies using these new techniques we have revealed the existence of specific acupoint-brain correlations\(^{[4]}\). Some of these correlations are summarized in Figure 1. For example, acupuncture points traditionally implicated for visual functions were shown to modulate the blood flow velocity of the corresponding cerebral arteries.

The middle cerebral artery (MCA) with its different branches can usually be investigated for example at a depth of 3 to 4 cm, and the media main trunk usually lies at a depth of 5.5 to 6.5 cm. Blood flow velocity in the internal carotid artery (distal part at a depth of 60 to 65 mm) as well as in the MCA can be determined by transtemporal entry. With increasing depth of measurement volumes, a part belonging to the anterior cerebral artery (ACA) can also be determined. If the ultrasound probe is turned slightly in the dorsal and caudal direction, the origin of the posterior cerebral artery (PCA) can be reached at a depth of 65 to 75 mm.

A restriction of intracranial TCD results could be ultrasound transmission through the skull. According to literature, particularly older women could be examined sufficiently in only 50% of the cases. However, optimal transtemporal registration was not possible in 5% to 10% of men and younger women either\(^{[4]}\).

In addition to the three transtemporal acoustic windows (front, middle and rear), transorbital and transnuchal entry for TCD-monitoring is also
possible (Figures 2A to 2C). Measurement of blood flow profiles in the ophthalmic artery (OA) was performed with a probe, applied lateral to the cornea on the closed bulb of the eye (Figure 2C). Reduction in transmission energy should be achieved as far as possible in order to avoid direct exposure of the lens to sonic waves. A signal from the OA is registered at a depth of 40 to 50 mm by a probe turned slightly in the central direction. The foramen magnum offers a further path of entry for ultrasound measurements (Figure 2B right). Dependent upon anatomical variations, the basilar artery (BA) lies at a depth between 70 and 110 mm.

2 Construction for measuring the effects of acupuncture

Special TCD ultrasound probe holder constructions were used to investigate the blood flow velocities simultaneously and continuously in different cerebral arteries in some basic studies. Specific effects of particular acupuncture points or acupuncture point combinations on two or more different arteries can be documented using this technique. Registation of ultrasound signals was performed with a Multi-Dop T device (DWL Electronic Systems GmbH, Sippling, Germany). A 2-MHz or a 4-MHz probe was used in most of the studies.

Blood flow velocity in the supratrochlear artery (STA), the inner endbranch of the OA, was measured transorbitally. For these examinations, the smallest possible value which still reveals assessible signals (maximum 20 mW/cm²) was used. The STA is largely constant and can be found isolatedly, without direct scanning of the bulbuss.

By placing a probe in the aforementioned, specially constructed holder at the inner canthus of the eye and parietal, without applying pressure, the STA was monitored. The angle and position of the sensor were changed under acoustic control until the largest possible signal amplitude was
reached. In addition, changes in the blood flow velocity of the MCA were registered simultaneously and continuously.

3 Ultrasound assessment parameters

The mean blood flow velocity \(v_m\) has proven to be an important parameter\(^4\). The advantage of this measurement value compared to the maximum value is that it can also be determined when an unfavorable signal-noise ratio is present. It can also be interpreted as the mean velocity of all blood cells present in the transverse section of the vessel.

The STA/MCA-Index has been introduced as a further assessment criterion\(^{[15]}\). This index represents the quotient from \(v_m\) of the STA and \(v_m\) of the MCA multiplied with the factor 100. The TCD-signals were measured continuously, and the changes in the flow profiles were documented exactly during the phases of stimulation with the needles. The signals were analyzed graphically and numerically\(^{[10]}\). For the ultrasound measurements in acupuncture research we have also developed innovative helmet constructions already in the late 1990s (Figure 3)\(^{[1,15,16-18]}\).

![Figure 3](image)

**Figure 3** Helmet construction

Equipment for the first proof of changes in cerebral circulation caused by acupuncture.

4 Results obtained with the new equipment developed in Austria

Already in 1997, our team was able to scientifically prove that acupuncture needles can increase blood flow velocity in the brain\(^{[16]}\). The computer- and robotic-controlled biosensors and probes integrated in a special measurement helmet, coupled with light, ultrasound and highly sensitive biotelectrical monitoring methods yield reproducible results indicating that the blood flow velocity in the MCA is higher and the oxygen supply in the brain is increased by acupuncture in healthy volunteers\(^{[1,15,16]}\).

In further investigations performed with healthy volunteers in 1999, we could prove that acupuncture does not only lead to general changes in blood flow velocity in the brain but to specific changes (namely, different regional localization; see Figure 1). Thus, stimulation of acupuncture points on the hand or outer side of the foot, for example, Zhiyin, which according to TCM are often connected to the optical system, leads to an increase in \(v_m\) in the PCA which supplies the occipital center of the brain. At the same time, the blood flow velocity in other cerebral arteries remains nearly unchanged. Comparative investigation of points at the inner edge of the foot did not show changes in blood flow velocity in this particular cerebral artery\(^{[11,14]}\).

A crossover design was used in the studies. Different acupuncture schemes in the same subjects were performed on different days to exclude the placebo effect during acupuncture as much as possible. Each person was treated with an optic acupuncture scheme A, which according to TCM should improve vision, and with another scheme B to improve perfusion in the MCA. When using the optic scheme, a significant increase in \(v_m\) in the STA and OA occurred, whereas the \(v_m\) in the MCA remained nearly unchanged. In reverse, scheme B led to a significant increase in \(v_m\) in the MCA with nearly unchanged flow profile patterns in the optic arteries. Several crossover studies with manual needle and also with laser acupuncture were performed and confirm the initial results of selective changes in cerebral perfusion after acupuncture\(^{[4,7,14,15,17-21]}\). Therefore, the stimulation of two different acupuncture schemes resulted in two different responses in the brain, and it could be demonstrated clearly that acupuncture has a specific effect. No placebo measurement is necessary within this crossover study design.

In a recent study of our TCM Research Center Graz in Austria, which was performed in 2010 in our acupuncture lab\(^{[22]}\), violet laser acupuncture has been investigated in context with blood flow velocity of the BA and MCA. The aim of this research was to provide selective evidence of specific effects of violet laser acupuncture on mean cerebral blood flow. Again a TCD construction was used to monitor blood flow profiles in the BA and MCA simultaneously and continuously. In that controlled study the acupuncture point Dazhui on the upper neck was tested with ten healthy volunteers\(^{[22]}\). In addition to an on/off-effect, violet laser stimulation increased the blood flow velocity in the BA significantly compared with the reference interval before laser acupuncture. In the MCA, only minimal, insignificant changes in blood flow velocity were seen. Metal needle acupuncture at the same point intensified the effects; however, blood flow profiles did not change significantly during and after stimulation with deactivated violet laser (placebo), see Figure 4\(^{[11,22]}\).

Our investigations performed with TCD demonstrate that acupuncture produces specific and reproducible effects on brain blood flow velocity. However, it
should also be mentioned critically that the study
designs and also our technology cannot explain
the underlying mechanism. In this context, in our
non-invasive investigations with TCD only changes
in $v_a$ were registered in big brain vessels (MCA,
PCA, ACA, etc.). For future investigations, it
would also be interesting to measure microcirculation
in small brain vessels; however, this measurement
procedure is very complicated at the moment and
mainly based on invasive methods.

5 Results from further international studies

A literature research concerning “acupuncture,
cerebral circulation and ultrasound” in the scientific
database PubMed resulted in $n=16$ peer-reviewed
publications (January 2012). Nine papers are
from our research group$^{5,12-22}$, four from Russian
researchers$^{23-26}$, two in Chinese language$^{27,28}$
and one in Korean$^{29}$). Our papers have already
been discussed in detail.

Already in the years 1985 to 1990, Russian
researchers investigated acupuncture in a multiple
modality treatment method in patients with closed
cranio-cerebral trauma$^{30}$. They found a positive
time-course of some electrophysiological parameters
which indicates the normalization of vegeto-
circulatory dysfunctions under the impact of acu-
puncture. This method was called refleroxotherapy.
This kind of therapy was also used in children$^{31}$. 
Electrical and laser acupuncture was applied in
two groups of 50 patients each who presented
initial manifestations of cerebral circulation insuffi-
ciency$^{24}$. Changes in the tone of the regional
vessels of the brain were objectively documented
following different acupuncture methods.

Also in China, TCD was already used in
31 children with cerebral atrophy. It was found
that acupuncture scalp therapy was able to speed
up the blood flow of different arteries, especially
in MCA and ACA$^{27}$. Electroencephalograph and
cerebral blood flow detection with TCD in
29 children with non-traumatic apallic syndrome
of various etiology was also performed by Russian
researchers in 2001$^{30}$. The changes in cerebral
blood flow appear to be a positive prognostic sign
in response to acupuncture treatment. Another study
concerning cerebral circulation and acupuncture
was performed in Hubei, China$^{28}$. This single-
blind, randomized controlled trial was performed
in 160 patients after ischemic stroke. The patients
were randomly divided into an acupuncture group
and a control group (80 patients each). The patients
in the acupuncture group were treated with
acupuncture at Zusanli (ST36) and Xuanzhong
(GB39). The authors concluded that acupuncture
at these two points can significantly improve cerebral
blood flow autoregulative function, cerebral
hemisphere collateral circulation comprehensive
function in patients of ischemic stroke. A Korean
researcher from Seoul investigated the effects of
hand acupuncture using TCD in patients with
insomnia$^{30}$. This author did not find objective
criteria that the cerebral blood flow changed after
receiving hand acupuncture therapy. However, data
from another Korean research team indicated that
Korean hand acupuncture can modulate extracranial
blood flow through collateral circulation, which
may affect the intracranial blood flow in migraine
patients$^{30}$. 

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7 Competing interests

There is no competing interests for this review.
REFERENCES


奧地利的高科技针刺——脑循环研究

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摘要: 在奥地利，有众多结合医学研究特别是中医学的研究机构，开展了大量相关研究。最近15年来，高科技针刺的研究在奥地利格拉茨医科大学取得了重要的发展。本文介绍了高科技针刺与脑循环和经颅多普勒超声检查（transcranial Doppler, TCD）。TCD 很早就被用于各种基础和临床研究，近10年来被广泛用于测量各种针刺疗法的疗效。根据多普勒的原理，超声波通过作用于给脑部供血的血管获取针刺引起的脑部血流动力学变化的信息。本文介绍了与针刺相关的 TCD 技术的基本概念，以及针刺刺激对脑部血流动力学的特异性影响。

关键词: 激光针刺；奥地利；脑血管循环；超声检查；血流速度；激光多普勒流量测定；综述