Regional cerebral metabolic changes after acupuncture by FDG PET: effects and methodology

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Abstract In order to investigate the therapeutic mechanisms of acupuncture points in cerebrovascular ischemic patients and normal volunteers, FDG PET was adopted. Changes in cerebral glucose metabolism and cerebral functional activity before and after electro-acupuncture treatment were studied in 12 normal volunteers and 11 cerebrovascular ischemic patients. The PET imaging was read by visual interpretation and calculated by semi-quantitative analysis. After acupuncture, cerebral glucose metabolism of the normal group is higher in the frontal lobe, temporal lobe, thalamus bilaterally and cerebellum contralaterally. The cerebrovascular ischemic patients had manifested greater response in their lesions than in their normal regions of the two tested groups, as well as than in their normal regions of the whole brain, after acupuncture treatment. The study shows that the regulatory effects of acupuncture on the central nervous system influence the brain at multiple-sections, multiple-directions and multiple-levels of brain function. It conforms to the holistic and bi-directions regulatory laws of acupuncture.

Keywords Positron emission tomography, Regional cerebral glucose metabolism, Acupuncture

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1 INTRODUCTION

Acupuncture exerting its effects is subject to intervention and control by the central nerve system; these effects may be due to involvement of regulation via specific and non-specific sensation conducting systems, as well as the sympathetic nervous system, extra pyramidal system, etc.[1] In 1990's, the result of SPECT brain perfusion study had demonstrated the meridians phenomenon by Jia.[2] FDG-PET imaging is propitious to research the effects of acupuncture on the central nerve system, which will be highly valuable for further illuminating the essence of acupoints and meridians phenomenon, the relation of points and peripheral nerves, and the effects that acupuncture exerts and regulates on the brain.

2 MATERIALS AND METHODS

2.1 Subjects

23 subjects were involved in this study, including age-matched 12 normal volunteers

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(7 males, 5 females) and 11 cerebrovascular chronic ischemia patients (7 males, 4 females). The normal underwent thorough medical screening, including a complete history and physical examination and neuroanatomical imaging. For the normal volunteer with a history of significant head trauma, psychiatric or neurological disorder would be have excluded. MRI and CT scan imaging was performed in ischemia patients before FDG PET scan. The results of MRI and CT scan had confirmed cerebrovascular ischemia.

2.2 Acupuncture methods

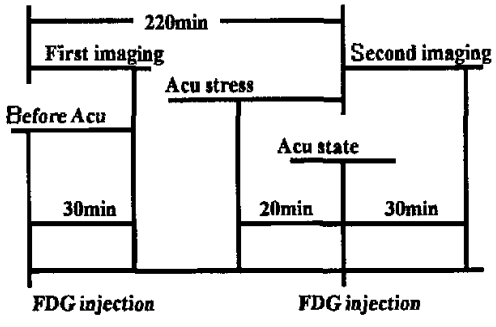
The subjects were treated with acupuncture of following points: Hegu (LI4) and Quchi (LI11) of Hand Yang-Ming meridian, Zusanli (ST36) and Shangjuxu (ST37) of Foot Yang-Ming meridian, and added Motor Area and Fengchi (B20). Limbs points were contralateral to the brain points. In the normal group, the side of the body treated by acupuncture was randomly selected and in the patients group, the sides treated was on the side of paralysis.

2.3 Image acquisition

FDG-PET scans were performed on an ECAT EXACT HR+ scanner. 148 MBq of FDG was injected intravenously following a 4 h fast. Patients were kept in a quiet, dimly room with eye and ear shielding. Images acquirsition was started after a 30 min uptake period. At the completion of the data acquisition, the images were reconstructed using an optimized Hanning filter.

2.4 Image procedure

Image procedure One-day method was established as follows:



PET imaging procedure of one-day method

2.5 Image analysis

A total of 89 elliptical regions of interest (ROIs) were placed on the transaxial planes.[3] The variability of the regional glucose metabolic rate after acupuncture was defined as follows:

$$\text{The ratio} = \frac{ROIe/(ROIe_{\text{white matter}}) - ROIr/(ROIr_{\text{white matter}})}{ROIr(ROIr_{\text{white matter}})},$$

where $ROIr$ is the radioactivity of an area of interest at rest, $ROIe$ is the radioactivity of an area of interest after acupuncture.

The data from this study were entered into a database and analyzed with T test. An analysis of variance of metabolic activity in the defined region was performed to determine differences. Difference would be considered to be significant with a probability value of less than 0.05.

3 RESULTS

Table 1 The ratio after acupuncture in normal subjects (n=12)

Region		Average increasing ratio of glucose metabolism in cortical regions		
		$x \pm s$	t (n=12)	p
Media frontal	Ipslateral	0.316531±0.163445	3.669899	<0.01
	Contralateral	0.290740±0.181093	3.042359	<0.01
Lateral frontal	Ipslateral	0.337583±0.199519	3.20631	<0.01
	Contralateral	0.365108±0.16127	4.290194	<0.005
Inferior frontal	Ipslateral	0.392452±0.187325	3.970085	<0.01
	Contralateral	0.251875±0.153729	3.104836	<0.01
Middle temporal	Ipslateral	0.271835±0.207773	2.479279	<0.05
	Contralateral	0.332509±0.206916	3.045217	<0.01
Superior temporal	Ipslateral	0.304181±0.252983	2.27851	<0.05
	Contralateral	0.363823±0.21557	3.198249	<0.01
Anterior temporal	Ipslateral	0.163120±0.213206	1.449828	>0.05
	Contralateral	0.268032±0.118099	4.300802	<0.005
Sensorimotor	Ipslateral	0.403211±0.298734	2.513756	<0.05
	Contralateral	0.360962±0.326811	2.153003	<0.05
Thalami	Ipslateral	0.398823±0.37343	2.020824	<0.05
	Contralateral	0.383799±0.35738	2.035086	<0.05
Parietal	Ipslateral	0.220431±0.14474	2.891331	<0.05
	Contralateral	0.297086±0.10183	5.528607	<0.005
Cerebellum	Ipslateral	0.153781±0.084337	1.832041	>0.05
	Contralateral	0.282377±0.139323	3.906095	<0.01

(1) PET imaging was read by visual interpretation in blind method and calculated by semi-quantitative analysis. These results show that cerebral glucose metabolism and cerebral functional activity of the normal is higher in the frontal lobe, temporal lobe,

thalamus, sensorimotor, parietal bilaterally and cerebellum contralaterally, etc (Fig.1). The increase ratio of ipslateral glucose metabolism was between 23% and 38%; while the contralateral increase ratio between 22% and 40%. Above all, the variation in cerebral glucose metabolism was predominantly in the contralateral cerebral regions (Table 1).

Table 2 The metabolism difference of ipslateral and contralateral regions after acupuncture in ischemia patients (n=11)

Region		Average increasing ratio of glucose metabolism in cortical regions		
		$x \pm s$	t (n=11)	p
Media frontal	Ipslateral	0.157152±0.165698	1.911079	>0.05
	Contralateral	0.200932±0.11114	3.642964	<0.01
Lateral frontal	Ipslateral	0.181458±0.195511	1.870169	>0.05
	Contralateral	0.197728±0.1347	2.957847	<0.05
Inferior frontal	Ipslateral	0.193911±0.124691	3.133583	<0.05
	Contralateral	0.19701±0.190312	2.086447	<0.05
Middle temporal	Ipslateral	0.177874±0.146992	2.438338	<0.05
	Contralateral	0.233195±0.131616	3.570145	<0.01
Superior temporal	Ipslateral	0.418102±0.175711	1.770983	>0.05
	Contralateral	0.400381±0.329726	2.416783	<0.05
Anterior temporal	Ipslateral	0.934373±1.55567	1.210338	>0.05
	Contralateral	0.816495±1.291733	1.273667	>0.05
Sensorimotor	Ipslateral	0.073443±0.114743	1.289519	>0.05
	Contralateral	1.458349±2.668552	1.101187	>0.05
Thalami	Ipslateral	0.113272±0.237198	0.96225	>0.05
	Contralateral	0.114824±0.137373	1.684256	<0.05
Parietal	Ipslateral	0.066912±0.148289	0.909225	>0.05
	Contralateral	0.267153±0.10293	5.229897	<0.01
Cerebellum	Ipslateral	0.147789±0.219781	1.354957	>0.05
	Contralateral	0.055706±0.269609	0.416338	>0.05

(2) The cerebrovascular ischemia patients had manifested greater response in their lesions than in their normal regions of the two tested groups after acupuncture treatment (Fig.2), the heightened range is 14%–40% (Table 2). The normal regions of the cerebrovascular ischemia patients group show similar changes with the normal group after acupuncture. The cerebrovascular ischemic patients had manifested greater response in their lesions than in their normal regions of the whole brain after acupuncture treatment.

Fig.1 Upper: rest state, Middle: acupuncture, Lower: after image subtract

Fig.2 Upper: rest state, Middle: acupuncture, Lower: after image subtract

4 CONCLUSION

(1) The methodology of brain FDG PET imaging before and after acupuncture in one day was set up. Using one-day investigative methods can avoid some factors, such as mental state and short of sleeping, influencing cerebral glucose metabolism. In traditional Chinese medicine, the wind stroke disease is also known as apoplexy, indicating extensively the cerebrovascular ischemic disease. According to the principle of selective points treating wind stroke, which is to wake brain in mind and to open in orifice, to tonify Qi and to nourish blood, to dredge meridian, so the subjects were treated with acupuncture points: Hegu (LI4) and Quchi (LI11) of Hand Yang-Ming meridian, Zusanli (ST36) and Shangjuxu (ST37) of Foot Yang-Ming meridian, and added Motor Area and Fengchi (B20).

(2) It is generally considered by modern medicine that the regulatory effect of acupuncture possesses a holistic and bi-directional law.[4] So-called holisticness means that puncturing acupoints may give rise to simultaneous influences on normal or abnormal function of the multiple organs and systems of the organism in different levels. So-called bi-directional reflection means that acupuncture may result in a counter-directional regulatory effect to correct function that departs from a wrong direction. This regulatory effect is to produce excitable-activity or inhibitory-activity. This study showed that in normal people kept in a calm setting, electro-acupuncture can apparently elevate cerebral glucose metabolism in specific regions of brain and provoke functional activity of the cerebral nervous system on the side of treatment. The FDG PET imaging shows that cerebral glucose metabolism is higher bilaterally in the frontal lobe, superior-middle temporal lobe, parietal lobe, cerebral sensory cortex, and thalamus, and is higher contralaterally in the cerebellum, hippocampus, and anterior temporal lobe, after acupuncture

treatment. This means that acupuncture on the central nerve system increases glucose uptake in certain specific regions of the brain. The specific regions whose glucose uptake are regulated by acupuncture, are affected at various levels of brain function and can be bilateral or contralateral. It has been shown that the regulatory effects of acupuncture on the central nervous system characteristically influence the brain at multiple-directions and multiple-levels of brain function. This conforms to the holistic regulatory laws of acupuncture. The response to acupuncture in cerebral ischemia patients was seen in both of the lesions and normal regions under the same condition of acupuncture treatment. A greater change was observed at the lesions, compared to the same area of the lesion on the contralateral side. This conforms to the dual regulatory laws of acupuncture. Therefore, clinical study of the effects of acupuncture on regulation of cerebral glucose metabolism by PET imaging has proved that the laws of acupuncture effect contributing to holistic and bi-direction regulation, and has deduced that these laws are dependent upon participation of the central nervous system.

(3) The study hinted that acupuncture therapy in cerebrovascular ischemic patients may improve their local cerebrocellar energy metabolism and restore their brain function as a result of acupuncture improving glucose uptake in certain ischemic regions of the brain and motivating functional activity of cerebral cell. It will support a definite theoretical basis for the clinic curative-effect of therapeutic mechanism of acupuncture in treating cerebrovascular ischemic disease. As the variation in cerebral glucose metabolism of cerebrovascular ischemic patients is most distinct contralaterally in the superiortemporal lobe, parietal lobe and bilaterally in the middle temporal lobe, etc., it is clewed by the research that there is a better curative effect to those infarction lesion with acupuncture therapy in patients. Yet to definite the influence of these acupoints on brain function in certain regions of the cerebrum, further study on acupuncture is still needed with respect to a controlled trial of puncturing non-points and the other meridian points.

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