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REVIEW ARTICLE

Effects and Mechanisms of Acupuncture Based on the Principle of Meridians

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Abstract
Acupuncture has been practiced in China for over 2000 years to treat a variety of diseases based on the "meridian theory" as described in the *Yellow Emperor's Classic of Internal Medicine*. To this date, the meridian theory continues to be an important guide for traditional Chinese medicine practitioners to diagnose and treat patients. Although the meridians have not been identified reliably as actual anatomical structures, they appear to serve as a road map to identify the location of various acupoints. Research has shown that acupoints overlie major neuronal bundles. The meridians extensively studied in the cardiovascular realm are the pericardial meridians (P) 5, 6, which overlie the deep median nerve. Meridians involved with gastrointestinal processes are (St) 36, 37, which overlie the deep peroneal nerve. Acupuncture needles, either manipulated manually or stimulated using a low current and frequency, have been documented to be a neurophysiological basis for modulating the activity of peripheral and central neural pathways. This review describes our current understanding of acupoints and meridians from a physiological aspect.

1. Introduction

Acupuncture is increasingly being used as a complementary therapeutic approach in the United States [1]. Manual acupuncture and its potent alternative, electroacupuncture (EA), have been used to treat a number of diseases in the Far East for centuries. However, many physicians who are trained in classic Western medicine are reluctant to recommend acupuncture, because its efficacy

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remains controversial and the physiological mechanisms determining its actions are largely unknown. This review briefly describes the various anatomical and physiological investigations carried out in the last 50 years.

2. Meridian theory

The meridian theory was proposed based on empirical experience accrued over many decades. For example, ancient doctors found that for treating stomach aches, needling certain pulsing loci on the medial part of the lower leg was more effective than needling any other region in the body. They drew lines to connect these empiric points on the body, making a visible map of the 14 meridians, each of which correspond to various but specific organ systems.

Over the last century, researchers have tried to scientifically identify these meridians and acupoints on the body. Nakatani and Yamashita [2] reported that different areas of the body can have abnormally higher or lower conductivity, and that such abnormal conduction is very closely related to the meridian lines. These areas have been called "Ryodoraku channels," meaning *a good conduction line*. Other investigators have failed to replicate the observations made by Nakatani and Yamashita due to pressure artifacts from electrodes and the influence of sweat glands in the palm innervated by sympathetic nerves, which are sensitive to psychological inputs [3,4].

3. Anatomical structures of acupoints

In 1973, a group of Chinese researchers found that there were no unique structures under acupoints; if there was something, the researchers suggested that they must just be nerves and nerve endings [5]. Yu et al [6] studied the three-dimensional structure of Neiguan (PC-6) and found that normal tissues, including receptors and nerve endings, contribute to these acupoints, but that these tissues were not unique to these locations. Other researchers reported that in normal adults, vascular occlusion of the upper arm could not prevent the analgesic effect of acupuncture needling of a point on the hand [7]. Conversely, the infiltration of procaine, a local anesthetic, into the deep tissues around the point of acupuncture entirely abolished the analgesic effect, suggesting that nerves rather than humors were mediators of this response.

In 1978, Kline et al [8] reported that the electrical stimulation of the Zusanli acupoints elicited significant decreases in arterial blood pressure and heart rate when the tip of the needle was close to branches of the peroneal nerve. However, cutting the sciatic nerve or paralyzing the animal using succinylcholine or gallamine abolished these responses, whereas direct stimulation of the intact peroneal nerve continued to decrease arterial blood pressure and heart rate in paralyzed animals. Their results suggested that the responses to acupuncture were due to the activation of motor fibers that resulted in the contraction of muscles and subsequent excitation of muscles and/or joint receptors, which elicited an inhibitory reflex. They also demonstrated that there was no significant depressor effect if the acupuncture needle was inserted at a control point in close proximity to somatic nerves.

In 1984, Dung [9] listed the following anatomical structures found in the vicinity of acupoints: large peripheral nerves; nerves emerging from a deep to a more superficial location; cutaneous nerves emerging from deep fascia; nerves emerging from bone foramina; motor points of neuromuscular attachments; blood vessels in the vicinity of neuromuscular attachment; along a nerve that is composed of fibers of varying sizes; bifurcation points of the peripheral nerves; ligaments rich in nerve endings; and suture lines of the skull. These observations confirmed that there were no particular structures that were unique to acupoints. The prevalent finding that nerve bundles were involved in almost all such locations was also validated previously.

Additional details about the structures underneath the acupoints were described in some anatomical atlases of acupoints [10]. These details can be summarized as follows. Acupoints on the face and forehead region are located along the terminals or cutaneous branches of the trigeminal and facial nerves. They are either at the nerve trunks as they exit the foramina or at the tip of a terminal branch. Occasionally, they can be found at the anastomotic site of two different nerves or at the points at which a nerve branches bilaterally. In the external ear, there exists many lateral acupoints that can be used to treat different diseases, due to a heavy concentration of nerves stemming from the vagus, glossopharyngeus, and the combination branches of the facialis and occipitalis minor nerves. The medial ear also receives branches from the auriculotemporal, auricularis magnus, and occipital major nerves. This feature provides the anatomical basis on which acupuncture applied on the auricle could treat a multitude of visceral and somatic diseases.

On the trunk, typical spinal nerves have six cutaneous branches that reach the skin in the thorax and abdomen. Each of these branches corresponds to the splanchnic organs that are in the same or nearby spinal segments.

On the forearm and hand, acupoints are mostly related to the radial, median, and ulnar nerves, and are often used to treat diseases in their respective dermatomes as well as diseases on the head, face, and in the chest. The acupoints on the lower limbs are related to the sciatic and femoral nerves as well as their branches such as the peroneal and tibial nerves. Such locations are generally used to treat diseases of the lower limbs as well as those located within the abdomen or pelvis.

Using histological analysis, Croley [11] showed two-times as many papillae in the area of acupuncture points as non-acupoints. There was a high concentration of dermal papillae containing capillary loops with sympathetic nerve endings. Within the group of acupoints innervated by superficial somatic nerves, most fibers appear to be unmyelinated.

3.1. What kinds of nerve fibers are activated by acupuncture?

The essential correlate of analgesia by acupuncture has been known as "De-Qi sensation," a feeling of numbness, fullness, and sometimes soreness. Experimentally, however, intramuscular injection of procaine abolishes this feeling as well as the analgesic effect of acupuncture.