Meridian Studies in China: A Systematic Review

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Abstract
Meridian theory is a major part of Chinese medicine and has guided acupuncture and clinical practice for thousands of years. Meridian theory describes many important concepts about the rules of human body function and regulation, but has comparatively huge differences with the basic concepts of modern medicine. These differences have caused deep concern and attracted attention from scholars, both inside and outside of China. The interest in meridian theory lies in determining the structural nature of meridians. Not only is this information still unclear, it is very difficult to achieve clear results in a short period of time. Despite this, the phenomena of meridians can be used as the entry point for meridian studies.

After many years of effort, although the physical structure of meridians has not been found, the existence of the meridian phenomena has been fully confirmed. Although there is a lack of morphological evidence for the existence of the meridian, concluding non-existence may be incorrect as morphology techniques develop and structures previously not determined are being found. Since the phenomenon of meridians exists, some biological basis behind its occurrence must be present. This implies that research on meridians needs to continue as research techniques advance and may eventually reveal the biological basis of the meridian phenomenon. In the present review, we analyze the history of meridian studies in China.

1. The Origin of Meridian Studies in China

Meridians are passageways for the flow of “qi” and “blood”, which are the two basic bodily fluids in Chinese medicine. These passages include 12 standard channels, 12 collaterals, 8 extra meridians, 15 large collaterals, musculature of 12 meridians and 12 skin divisions. Meridians spread on the surface of the whole body vertically and horizontally, integrating the inside with the outside of the body. They also connect the inner organs, joints and extremities, thus transforming the whole body into one entire organ. As Chinese medicine attaches great importance to the concept that all body functions are under the complete state of one organism, the black-box theory was adopted in its research [1]. The theory pays attention to changes in outside phenomena, as such, its theoretical system lacks an anatomical basis. However, along with the development of modern medicine, people gradually realized that acupuncture, that follows the meridian theory, has the best outcomes; traditional Chinese medicine believes that the therapeutic effects of acupuncture are achieved through the meridian system. Additionally, by studying a number of skin diseases, propagated sensations and the migration of isotopes along the meridians (Figures 1, 2 and 3,
medical knowledge. Meridian study and research therefore attracted a lot of interest.

In 1963, Dr Bonghan Kim from North Korea [5–7] announced the discovery of the meridian anatomy and structure, and named them “Bonghan duct” or “Bonghan capsule”. Bonghan’s work however failed to be repeated and was widely questioned. The Austrian expert Kellner stated that the structure Bonghan found exists, but was only a remnant from development, and could not support the function of the meridian system [8,9]. At the same time, China planned to systematically duplicate Bonghan’s work but failed to support Bonghan’s conclusions, and the repeated work has not been published. Nevertheless, during the repetition of Bonghan’s work, a meridian research team was organized and marked the beginning of meridian study in China. Prior to this, only a few histological studies into acupoints had been conducted in China (Table 1 [10–21]).

2. The Main Significance of Meridian Studies in China

2.1. Investigations into propagated sensation along meridians

The effects of acupuncture rely on the integrity of the nervous system, thus the study of meridians focusing on the neural aspect has become commonplace. In the 1950s, Professor Xi-Jun Zhang stated that action of the meridians is accomplished through neural reflection [22]. From a gross anatomy perspective, meridian and acupoint regions are always richly innervated. Moreover, the meridian and peripheral nervous systems are roughly very similar in their path around the body, especially below the elbow and knee joints where the meridians are almost along the path of the nerve trunks and their main branches. Descriptions of meridian function in classical Chinese medical records are also closely related to the nervous system. Therefore, meridian research from the neural perspective may still be highly fruitful.

Propagated sensations along channels (PSC) is a meridian phenomenon which was investigated in over 100,000 people over 20 provinces in China in 1970s. These studies revealed that approximately 0.3% of people exhibited PSC. PSC is considered a window for revealing the substance of the meridian. However, this propagated sensation is a subjective feeling, and must therefore be associated with the central nervous system, particularly the sensory cortex. This has led some researchers to believe that PSCs are an expanding excitement occurring within the sensory cortex [23]. However,
this viewpoint may not stand as propagated sensations accompany reactions of the skin, blood vessels and nerves. Furthermore, PSC can be blocked by mechanically pressing on the meridians [24]. As PSC can be stopped by outside pressure, it is reasonable to presume that a form of active factor is involved in the formation of PSC [25]. Myoelectricity along meridians could be one such factor [26]. Another explanation for propagated sensation caused by acupuncture may be related to the axon reflection of the peripheral nerves and the migration of histamine between the peripheral nerve terminals due to nerve-mast cell interaction [27]. Alternatively, the characteristic order of PSC could happen between α motor neurons, based on the column structure in the spinal cord [28]. However, the involvement of peripheral motive factor in propagated sensation still does not explain this phenomenon in pseudomelia; therefore, when elucidating the mechanism of propagated sensation, some researchers place an emphasis on central nervous processes [13,29–30]. The question is whether it is truly necessary to have a unique mechanism that explains all the phenomena of PSC. Perhaps multiple substances exist within both the peripheral and the central nervous systems to give rise to the different aspects of PSC.

2.2. Comments on the essence of meridians as a circulatory system

Neurology is a significant component in meridian research, and raises important questions in developing the research. Meridians certainly shares some common components with the nervous system. Furthermore, meridians certainly do not possess all nervous system structures and functions, or vice versa [31]. Thus, the study of meridians from

<table>
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<th>Time</th>
<th>Landmark events</th>
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<tr>
<td>1955</td>
<td><em>Study of Meridian</em> was translated from Japanese to Chinese by Dan-An Chen.</td>
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<td>1956</td>
<td>The study of meridian essence was classified as a key project of Natural Science Development Plan in China, where histological studies were carried out on acupoints.</td>
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<td>1963</td>
<td>“BHC” and “BHD” structures were reported by Bonghan Kim in North Korea.</td>
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<td>1964–1970</td>
<td>Meridian essence was studied mainly using morphological methods.</td>
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<td>1971</td>
<td>America president Nixon visited China; this induced the study of acupuncture-anesthesia widely.</td>
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<td>1972–1987</td>
<td>Propagated sensation along channels and other meridian phenomena were studied widely.</td>
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<td>1988–1992</td>
<td>Meridian study was classified as “7th five” plan, and the main content was migration of isotopes along meridians. <em>Biophysics of Acupuncture-Meridians: The verification of the first invention in China</em> was published (Zu et al, 1989 [10]). <em>Modern Research of Meridians in TCM Theory</em> was published (Hu et al, 1990 [11]). <em>Structure and Function of Meridians</em> was published (Zhang, 1992 [12]).</td>
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<td>1993–1997</td>
<td>Meridian study was classified as “8th five” plan, and the research content involved three parts: the mechanism of propagated sensation along meridians; the relationship between meridians and viscera; and the physical and chemical characters of meridians. <em>Clinical Meridians Phenomenology</em> was published (Liu, 1994 [13]). <em>What is the Meridians</em> was published (Zhang, 1997 [14]). <em>Soul of Gold Needle: The study of meridians</em> was published (Hu, 1997 [15]). <em>Classical Meridian Theory and Modern Meridian Theory</em> was published (Liu, 1997 [16]).</td>
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<td>1998–2002</td>
<td>Meridian study was classified as “9th five” plan, and the research content still involved the same three parts: the mechanism of propagated sensation along meridians; the relationship between meridians and viscera; and the physical and chemical characters of meridians. <em>Discovery of Fourteen Meridian Channels Image</em> was published (Meng et al, 1998 [17]).</td>
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<td>2002–present</td>
<td><em>Discovery of Meridians in TCM Theory</em> was published (Li et al, 2003 [18])</td>
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<td><em>Science of Meridians</em> was published (Zhang et al, 2003 [19]).</td>
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<td><em>Meridians Medicine: The decode of meridians cipher code</em> (Liu et al, 2007 [20]).</td>
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<td><em>Meridians and Collaterals are the Water Passages</em> was published (Zhang 2009 [21]).</td>
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BHC = Bonghan corpuscle; BHD = Bonghan duct.
the perspective of neurophysiology is unilateral. Classic medical books show that meridian and blood vessel naming are closely related, especially in older texts [32, 33]. The original meaning of “Mai” is blood vessels [34]; studying the meridians as a circulatory system may also be valid [35,36]. From a functional point of view, not only vessels themselves [37], but also the nerves in the vessel walls [38], and even the rhythm in the microvascular networks of the meridian system [39] have gradually become areas of interest for researchers. Moreover, the lymphatic system is also closely related to the meridian system [40,41]. However, some academics oppose the theory that a relationship exists between meridians and the circulatory system. They believe that the movement of liquid in the vessels cannot form the propagated sensation, and hence the circulatory system cannot be equated to meridians [42,43].

2.3. Investigating the substance of meridians from the aspect of interstitial fluid flow

Since meridian function is identical to neither the nervous system nor the circulatory system, then why do meridians transport qi and blood as described in the classic Chinese medicine theory and how is this accomplished? The most direct way to solving this issue is to observe how radio-labeled material migrates in meridian lines. One study using this technique showed 14 meridian lines in more than 90% of cases based on a sample of 1000 participants [44]. The migration routes were neither blood nor lymph vessel [45]. Only micromolecules can migrate along the meridians, and this migration is powered by the different pressures generated by blood and lymph circulation [46]. The migration routes are not only continuous [47], but also consistent with meridian lines [48]. Based on the above experiments, Professor Wei-Bo Zhang proposed the Low Hydraulic Resistance Channel Theory [49]. He believes that the interstitial substance is heterogeneous, meaning that some parts have high permeability and low resistance to the flow of interstitial fluid, and thus form a low hydraulic resistance point [50]. Adjacent low hydraulic resistance points can transfer the hydraulic wave, indicating the connection among these points, thereby forming a channel [51,52]. By measuring hydraulic resistance, transmission of the pressure wave and migration of the isotope, low hydraulic resistance channels were found along meridians which are believed to be the main body of the meridians [53–56]. Zhang also put forward a neural-fluid transmission model to explain the effect of acupuncture and PSC, based on the low hydraulic resistance channel (Figure 4 [57]).

From the perspective of modern microcirculation, there is a minute gap between end capillary vessels and interstitial fluid cells. The transportation of nutrients, exchange of information, as well as the removal of metabolic waste not only depend on the diffusion gradient, but also convection of interstitial fluid. However, the process of interstitial fluid flow still remains unknown. In recent years the concept of a tissue channel has provided a breakthrough point for solving these problems.

![Figure 4](image-url)
It allowed the movement of interstitial fluid pathway to be shown [58], and illustrated that the function of the interstitial fluid pathway coincided with the function of meridians [59]. Furthermore, based on the fact that capillary vessels and collagen fibers at the location of acupoints are arranged in the direction of the meridians, it has been proposed that the directional flow of interstitial fluid is closely associated with meridians [60]. Professor Wei-Sheng Yang has performed skin impedance studies for many years and found that meridian lines have low impedance [61,62]. The cause of this low resistance characteristic was thought to be due to the relatively high amount of interstitial fluid and the histological nature of the meridians, which are rich in loose connective tissue [63,64].

As interstitial fluid pressure is lower than atmospheric pressure, and the changes in interstitial hydraulic pressure have a direct impact on the lymphatic return and efficiency, an objection against the view that interstitial fluid flow along the meridian line was raised. Researchers Wei-Bo Zhang, Guang-Hong Ding and Wei-Sheng Yang all have a solid background in physics, yet proposed different opinions on the same issue. W.B. Zhang put forward the view that meridians are open channels of interstitial fluid, without giving the direction of flow; Ding emphasized a certain direction for interstitial fluid flow; Yang emphasized the accumulation of interstitial fluid in the connective tissue, neither considered the movement of the interstitial fluid or its direction.

2.4. Studying the substance of meridians from the perspective of connective tissue

In the early times, some studies noted the relationship between meridians and connective tissue, suggesting that the meridians and connective tissue are similar in many areas [65,66]. While interpreting the meridian phenomena, many theories such as the quantum theory [67] and the structure of crystal fluid [68], emphasized the role of connective tissue. According to anatomical studies, the shape and structure of meridians is closely related to the connective tissue in parts of the lung meridian [69], gall bladder meridian [70,71], and stomach meridian [72]. In functional studies, the relationship between the direction of collagen fibers along the meridian and acupoints, and the function of meridian and acupoints have been particularly emphasized [73]. A number of studies using automatic computerized markers and three-dimensional reconstruction techniques, found an extreme similarity between the interval connective tissue fascia and the meridian longitudinal position. A model was then proposed for the study of the fascia of meridians [74–76], as the function of this membrane structure is to maintain the stability of the interior body, and also is the specific reflection of meridian substance in the human body.

3. The Relationship Between Mast Cells and Meridians

As mast cells are widely distributed in connective tissue and are also involved in various rapid physiological responses, their relationship with the meridians has received attention. Mast cells are thought to play a key role in acute allergic reactions. They also participate in delayed type hypersensitivity [77], and fighting against bacterial [78,79] and parasitic infections [80]. Studies focusing on mast cell function have clearly shown that their role is far beyond what was previously understood. Mast cells are now considered to be multi-potent and involved in maintaining the stability of the interior body [81,82].

Ji-Mei Song [83] in 1977 first proposed that mast cells participate in the propagation sensation. This is followed by a series of studies which showed that the trend in the distribution of mast cells is to follow the meridian line [84–85]. Moreover, along the low impedance line of the meridians, the number of mast cells in different layers of skin was significantly higher than the control area [86]. Some researchers have questioned the role of mast cells in the function of meridians [87], but evidence that mast cells are involved in the activities and functions of meridians has been found. In many organs mast cells are located very close to the nerves [88,89], and these nerves often contain substance P, peptides related to the calcitonin-gene, and other neurotransmitters and neuromodulators [90]. Under appropriate stimulus, the nerve endings would release peptide-like substances, and mast cells would express the receptors for these substances [91,92]. The activity of neurons would then lead to activation of mast cells to release granules or neuromodulators [93]. Substances released by mast cells would in turn act on nerves, and affect their function [94]. On the meridian line, skin nerves and mast cells can establish functional links [95–98]. Acupuncture stimulation can act to increase not only the number of mast cells [99], but also promote mast cell degranulation [100–103]. Acupoint injection with mast cell granule contents, such as substance P, histamine [104] and neurokinin-A [105] have been reported to cause a significant increase in afferent nerve discharge, indicating that active substances released by mast cells participate in the formation of propagated sensation [106].
4. Detecting Special Chemical Characteristics Along the Meridians

Since meridian channels have their special path and function, the composition of the material found in the meridians might be different from their surrounding areas. The effect of acupuncture can be transferred through the meridian path, suggesting that these paths have a higher excitability, which may be due to the excitatory threshold determined by trans-membrane ion concentration difference and ion flow. The transmission of information necessarily has its carrier. Therefore, it seems that investigating the structure and function of meridians by studying the changes of chemical substances along the meridians is particularly important.

Among all basic ions, calcium ions are involved in the meridian activities [107,108]. Acupoints are Ca\(^{2+}\) enriched [109,110]; acupuncture can also further increase Ca\(^{2+}\) concentration in the area of the acupoint [111], which has given rise to the belief that the effect of acupuncture relates to a surge of Ca\(^{2+}\) [112]. Ion-specific research on meridian lines has not been limited to Ca\(^{2+}\). Other ions, such as Na\(^+\) and K\(^+\), are also involved in the functional activities of meridians [113–115]. Based on the above understanding, it has been suggested that the human body meridian system is the body’s bio-electrical network of ion channels, within which the flowing substances are K\(^+\), Na\(^+\), Cl\(^−\), Ca\(^{2+}\) and other ions. As a result acupoints, the meridians have low impedance and high electrical conductivity properties [116]. The organism excitatory threshold is directly related to the accomplishment of energy metabolism, the higher the excitability, the more vigorous the metabolism should be, which in turn directly relates to both oxygen consumption and carbon dioxide production. Therefore, the presence of carbon dioxide along the meridians would be an important indicator for meridian activity. Transcutaneous CO\(_2\) emission (TCE) refers to the CO\(_2\) emitted from skin and produced from the tissue when the citrate cycle takes place in living cells. TCE along the meridians is higher in healthy people [117]. Moreover, the relativity of TCE is higher between Yuan-points of the exterior-interior meridian couples and same name meridian couples [118]. Also the relativity of TCE is higher on the acupoints in one meridian [119].

Under pathological conditions, there is an imbalance in the TCE between the left and right acupoints with the same name [120]. Acupuncture can act to increase the TCE [121] and diminish the oxygen from the meridians [122]. This decrease in oxygen content is definitely not due to reduced blood flow, but an indication that acupuncture can enhance organic metabolism. Vigorous metabolism in the organism implies an abundant blood supply, leading to a rise in temperature, causing a stronger infrared radiation. Research has shown the existence of linear bands of infrared radiation orbits on a healthy body, and these radiation bands are highly similar to the routes of ancient meridians [123–126]. The high temperature strips along meridians can be induced by different types of acupuncture [127]. The strips become more striking when heating the acupoints or meridians [128]. When there is pathology in internal organs, higher temperature along the meridians may occur [129,130]. Rabbits with cholecystitis present with a high temperature reaction along the gall bladder meridian [131]. From the above analysis we can see that in both physiological and pathological conditions, high temperature response along meridians can occur, suggesting that meridians have infrared or near infrared radiation characteristics.

5. Conclusion

Meridian study in China has a long, rich history and is multi-directional. Obtaining a unique understanding of meridians in a short time is difficult. Research is continuing to determine the correct answer to the age old question, “What is the meridian?”

Acknowledgments

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References


8. Kellner G. On a vascularized nerve-ending corpuscle of the Krause end-organ type. Z Mikrosk Anat Forsch 1966;75:130–44. [In German]


27. Zhang BZ. Discussion about the skin reaction along the meridians and the morphological and physiological basis of the PSC. J Xian Jiaotong Univ (Med Sci) 1984;5:90–2. [In Chinese]


49. Zhang WB. What is Meridian? Science and Technology Publishing Company, 1997:60. [In Chinese]


51. Zhang WB, Jing XH, Li CH, Lui YT, Zhang LJ, Li ZC. The transport of interstitial fluid pressure wave in subcutaneous tissue on and beside the stomach meridian in rats. Biomed Eng (Beijing) 1995;14:40–3. [In Chinese]


58. Tian N, Zhao XM. The importance of tissue channel on the development of medicine and biology. *Chin J Microcirc* 2006;16:1–3. [In Chinese]


66. Zhen LY. Channels may be functional zones adhering to certain tissues. *Zhongguo Zhen Jiu* 2001;20:35–6. [In Chinese]


70. Tao KZ, Chen EY, Dang RS, Shen XY. Relationship between some acupuncture points of Gall Bladder and Stomach meridian in crural area and muscle origins and calcium accumulating area. *Chin J Anat* 1998;20:504–6. [In Chinese]

71. Chen EY, Shen XY, Dang RS, Cheng HS, Cai DH, He WQ, et al. A relationship between connective tissue and accumulation of calcium with points on the GB channel below the head. *Shanghai Zhen Jiu Za Zhi* 1998;17:36–8. [In Chinese]


86. Li M. Effects of electroacupuncture on the number of subcutaneous mast cells in and beside the acupoint and the inflammatory pain focus in the rat. *Zhongguo Zhen Jiu* 2003;23:597–601. [In Chinese]


100. Deng YP, Zeng T, Guan XM, Zhou Y. The influence of electro-acupuncture on some elements at meridian acupoints by PIXE. *Yan Jiu Zhen Ci* 1999;22:506. [In Chinese]


106. Guo MX. Advances in research on substance basis of meridian, propagated sensation along meridian and mechanisms of meridian actions. *Chin J Clin Rehabil* 2004;8:5353–5. [In Chinese]


110. Tao KZ, Chen EY, Deng RS, Shen XY. Relationship between some acupucture points of gall bladder and stomach meridian in crural area and muscle origins and calcium accumulating areas. *Chin J Neuroanat* 1998;16:504–6. [In Chinese]


