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CME ARTICLE

Neuroembryology of the Acupuncture Principal Meridians: Part 3. The Head and Neck

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ABSTRACT

Background: Accumulating evidence from anatomical, physiologic, and neuroimaging research shows that Classical acupuncture points stimulate nerve trunks or their branches in the head, trunk, and extremities. The first part of this series revealed that phenomenon in the extremities. Principal meridian distributions mirror those of major peripheral nerves there and Classical acupuncture points are proximate to peripheral nerves there. These relationships were shown to be consistent with the linear neuroembryologic development of the extremities. The second part of this series revealed that, in the trunk, a neuroanatomical basis for the Principal meridians exists consistent with lateral folding in early fetal neuroembryologic development.
Objective: The aim of this Part is to provide anatomical data that corroborates a neuroanatomical basis for the Principal meridians in the head and neck, which is consistent with the longitudinal and lateral folding that occurs in early fetal neuroembryologic development.
Methods: Adobe Photoshop software was used to apply Classical acupuncture points and Principal meridians as layers superimposed on neuroanatomic images of the head and neck, allowing demonstration of their anatomical relationships.
Results: The Principal meridian distributions in the head and region can be conceptualized as connecting branches of the cranial and/or cervical spinal nerves.
Conclusions: Anatomical data support the conceptualization of acupuncture Principal meridians in the head and neck as connecting branches of the cranial and/or cervical spinal nerves and are consistent with neuroembryologic development. Overall, the acupuncture Principal meridians can be conceptualized to have a neuroanatomical substrate that is corroborated by developmental neuroembryology.

Keywords: acupuncture, mechanism, peripheral nerve, meridians

INTRODUCTION

The Yellow Emperor (Huang Di), who reigned ~2700 BC, is credited with the discovery of both acupuncture and writing.[1] The first major source of information on acupuncture theory and practice derives from the Inner Classic (*Nei Jing)* treatise dated to the second century BC. The *Nei Jing* has two parts, the Simple Questions (*Su Wen*) that describes Traditional Chinese Medicine (TCM) theory, and the Spiritual Pivot (*Ling Shu*) that focuses on the practice of acupuncture.[2] Although many allopathic physicians do not consider the foundations of Traditional Chinese Medicine to be ''scientific,'' the *Nei Jing* actually discussed the circulation of Blood in the body nearly 1800 years before the British physician Harvey subsequently described this in 1615,[3] and the *Nei Jing* also discussed the concept of

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circadian rhythms some 1900 years before French botanist Dr. de Mairan described this phenomena in plant leaves.[4]

The analysis of developmental embryology and adult human anatomy in Parts 1 and 2 of this series demonstrated the fundamental overlap of the distributions of acupuncture Principal meridians and peripheral nerves in the trunk and extremities.[5,6] The sympathetic autonomic nervous system distribution was shown to parallel that of the peripheral nerves (and thus the Principal meridians) via its contribution to spinal nerves.[7] There is somatopic organization of nerve fibers within distal nerve fascicles,[8] which, in turn, contain bundled organizations of sympathetic nerves (particularly in smaller nerve fascicles).[9] This provides a plausible physiologic mechanism of how stimulation of a given acupuncture point could affect autonomic nervous system (ANS)—and thus organ—function selectively.

The overlap of nervous system physiology with acupuncture physiology in the trunk region was presented in the second part of this series.[6] The known thoracic and lumbar-spine levels that provide sympathetic ANS innervation to any given organ were shown to correspond strongly to the spinal levels where the acupuncture back *Shu* points are inserted to influence that organ's function.[6,10]

This third part of the series explores the embryologic development of the head and neck region and how it leads to correspondences of the peripheral nervous system and acupuncture Principal meridians there.

METHODS

Using Adobe Photoshop Elements software (Adobe Systems, Inc., San Jose, CA), anterior and posterior perspective diagrams of the human head and neck were modified to apply peripheral nerves, arteries, acupuncture points, and meridians as separate graphic layers using the Netter and Clemente texts as anatomy references[11,12] and the O'Connor and Bensky text as the acupuncture reference.[10] This enabled superimposition of peripheral nerves and meridians over the head and neck to allow visual comparisons of their relationships. Confirmation of these anatomical relationships was performed using the Primal *Anatomy for Acupuncture*[13] virtual human and Chen's[14] cadaveric acupuncture *Cross-Sectional Anatomy of Acupoints*. The embryologic reference used was Moore and Persaud.[15]

RESULTS

Embryologic Considerations—Face and Neck Development

As shown in Figure 1, by 3 weeks postconception, the primitive streak forms in the midline at the caudal end of the embryo adjacent to the cloacal membrane and the primitive node (knot) forms at the rostral end. Mesenchymal cells from the primitive streak will produce the embryonic mesodermal and endodermal layers. The notochordal process and overlying neural tube extends in the midline rostrally from the primitive node to the prochordal plate, the site of the future stomatodeum.

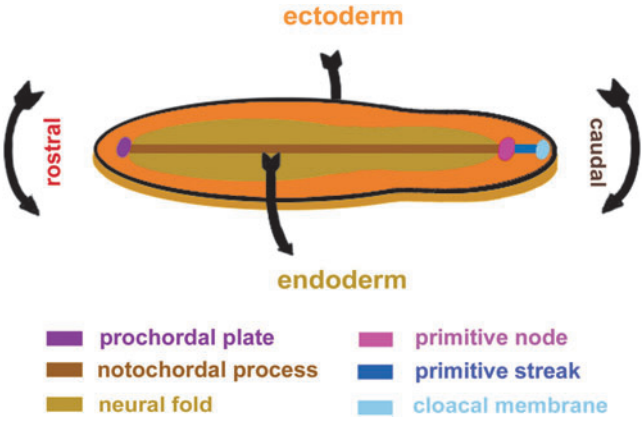

FIG. 1. Lateral and ventral folding of the developing fetus at the third week.

The notochordal process transforms into the notochord, which eventually becomes the foundation of the adult axial skeleton. At the region of the prochordal plate, the notochord and adjacent ectodermal neural plate induce the differentiation of the frontonasal prominence, (Fig. 2) which forms the forehead, nose, and the philtrum terminating at the rostral aspect of the stomatodeum.

By the third week postconception, the two lateral halves of the embryo fold laterally (Fig. 1) to join in the midline anteriorly to form the pelvic, abdominal, and chest cavities. Simultaneously, in the neck and mandible regions, the branchial arches fuse in the midline to form the anterior neck and mandible terminating at the caudal aspect of the stomatodeum (Fig. 2).

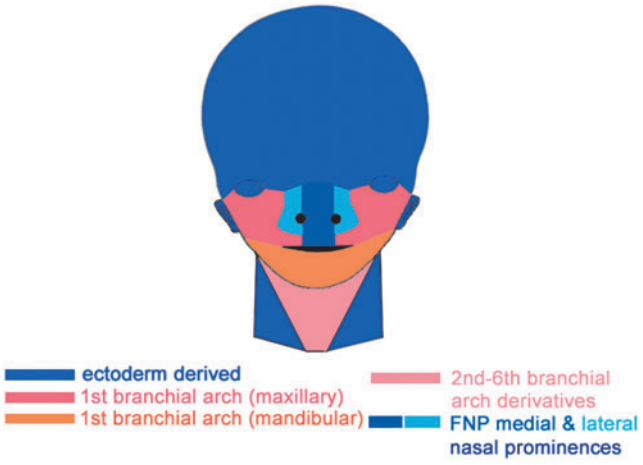

FIG. 2. Development of the frontonasal prominence by ~8 weeks (ectoderm-derived structure blue hues, branchial arch derived structures pink-orange hues). FNP, frontonasal prominence.

The first branchial arch derivatives include the mandibular prominence, which forms the mandible, and the maxillary prominence, which forms bones, including the upper jaw (maxilla), zygomatic, and the squamous portion of the temporal bone. The temporalis, masseter, and pterygoid muscles derive from the first branchial arch, as does the trigeminal nerve. The muscles of facial expression and the facial nerve derive from the second branchial arch. In the neck region, the embryonic lateral fold anteriorly meets the second, third, fourth, and sixth branchial arch–derived structures in the anterior neck, which include the hyoid bone, and the thyroid and cricoid cartilages. The trapezius and sternocleidomastoid muscles possibly might develop from occipital myotomes, but, more likely, these muscles derive from pharyngeal myoblasts. The most anterior somite derived mesodermal structure in the neck then is the sternocleidomastoid muscle, while the platysma and the muscles underlying and anterior to the sternocleidomastoid muscle derive from the branchial arches (Fig. 2). The formation of the perineal body occurs as the urogenital sinus divides the cloacal membrane at $\sim$7 weeks.

The Governor and Conception Vessel Meridians' Distributions

The courses of the Governor Vessel and Conception Vessel meridians, including their head and neck regions, can be shown to exist by 8 weeks postconception.

The early distribution of the Governing Vessel meridian can be seen at 3 weeks conception as extending from the primitive node along the midline notochordal process to the prochordal plate, but this meridian can be seen even more clearly by 8 weeks postconception as the rostral fold occurs along with differentiation of the frontonasal prominence (Fig. 2) to form the forehead, nose, and the philtrum terminating at the rostral aspect of the stomatodeum. This midline development from the primitive node to the philtrum ending at the primitive mouth accurately defines the course of the Governor Vessel meridian (Fig. 3), which exists in the dorsal midline of the Yang/sympathetic aspect of the body consistent with TCM theory.

The Conception Vessel meridian can also be shown to form by 8 weeks conception as well, extending from the perineal body, then ascending ventrally in the midline, where the lateral folds meet to form the abdominal and thoracic cavities before ascending up the midline of the neck, where the third to sixth branchial arches meet to terminate finally at the tongue base (Fig. 3). The Conception Vessel meridian exists on the ventral midline of the Yin/parasympathetic aspect of the body, consistent with TCM theory.

These meridian relationships are shown in Figure 3, superimposed on the Yang/sympathetic and Yin/parasympathetic mapping of the body discussed in Part 2 of this series.[6]

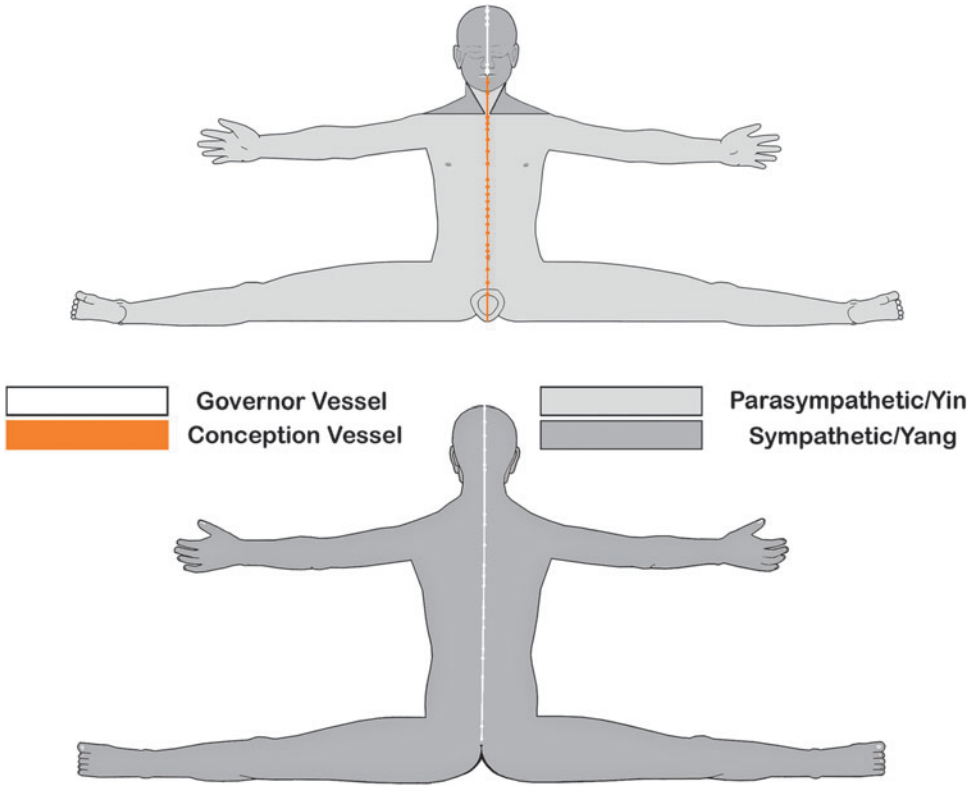

FIG. 3. Conception Vessel and Governing Vessel meridians superimposed on autonomic mapping (CV in orange and GV in white).

Anatomical Basis of the Principal Meridians in the Head and Neck

Note that the foramen in the skull in the frontal view have a remarkably linear relationship (Fig. 4) despite the complex folding of the frontonasal prominence and branchial arch derivatives that occur as the skull is formed. As shown, the line connecting the infraorbital and mental foramen below the orbit defines the anterior portion of the Stomach meridian on the skull. The continuation of this line above the orbit passes through the supraorbital foramen and is in the distribution of the Gallbladder meridian in the frontal region. The line extending vertically from the medial aspect of the orbit is in the distribution of the Bladder meridian in the frontal region.

If the branches of the trigeminal nerve are superimposed on this diagram, as in Figure 4, then the fundamental overlap of the distributions of the Principal meridians shown with branches of the trigeminal nerve are evident. The Bladder meridian over the frontal region of the skull overlaps the distribution of the infratrochlear and supratrochlear branches of the first division (V1) of the trigeminal nerve. The Gallbladder meridian over the frontal region corresponds well to the distribution of the supraorbital branch of V1. The anterior portion of the Stomach meridian on the face corresponds strongly to the infraorbital branch of the second division (V2) and the mental branch of the third division (V3) of the trigeminal nerve, while the posterior/lateral portion of the Stomach meridian on the face corresponds well with the zygomaticotemporal branch of V2 and the buccal branch of V3. Arterial vessels accompany these various trigeminal nerve branches, as documented in Figure 554 of the Clemente anatomy reference.[12] A cadaveric confirmation of the anatomy described above is shown in Figure 5.

Thus, consistent with the *Nei Jing* ~2200 years ago, Blood and energy (Qi) course through the meridians.

The rest of the correspondences of peripheral nerves and Principal meridians in the head and neck are discussed one meridian at a time in the sections below.

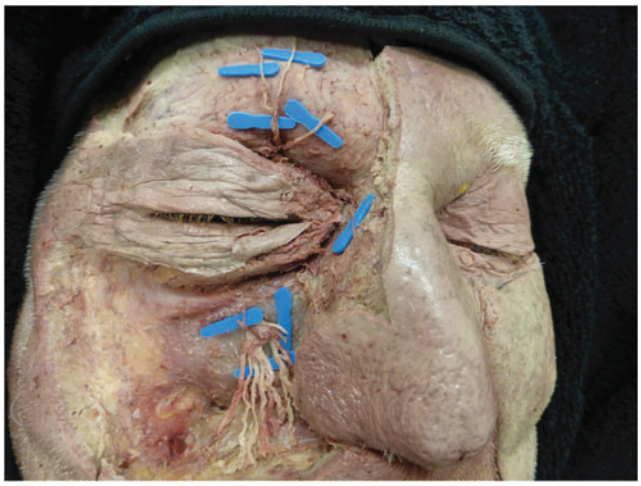

FIG. 5. Cadaver showing supraorbital, infraorbital, and infratrochlear nerves.

Bladder Meridian

The Bladder meridian in the head and neck region is defined anteriorly by the infratrochlear and supratrochlear branches of the trigeminal nerve ophthalmic division (V1) and posteriorly by the greater occipital nerve (Fig. 6). Clemente's Figure 553 documents that the greater occipital and supratrochlear nerves anastamose anterior to the skull vertex.[12]

Gallbladder Meridian

The neuroanatomical basis for the Gallbladder meridian in the head and neck region is depicted in Figure 7. The superior portion of the Gallbladder meridian there is defined by the supraorbital branch of the ophthalmic division (V1) of the trigeminal nerve anteriorly and the lateral branches of the greater occipital nerve posteriorly. The inferior portion of the Gallbladder meridian on the head is defined by the zygomaticofacial and zygomaticotemporal branches of the

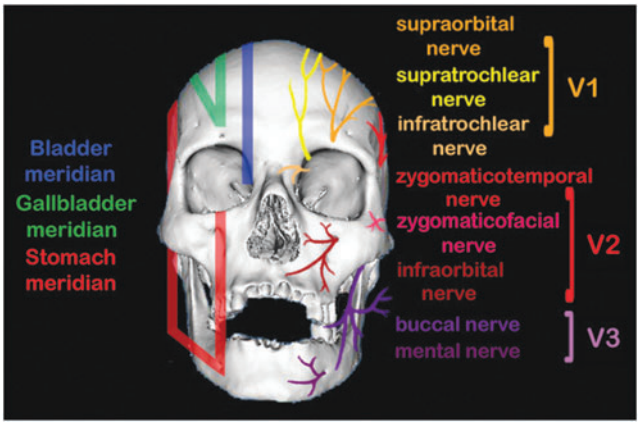

FIG. 4. Skull foramen (*left*) and trigeminal nerve branches (*right*) and their relationship to Principal meridians.

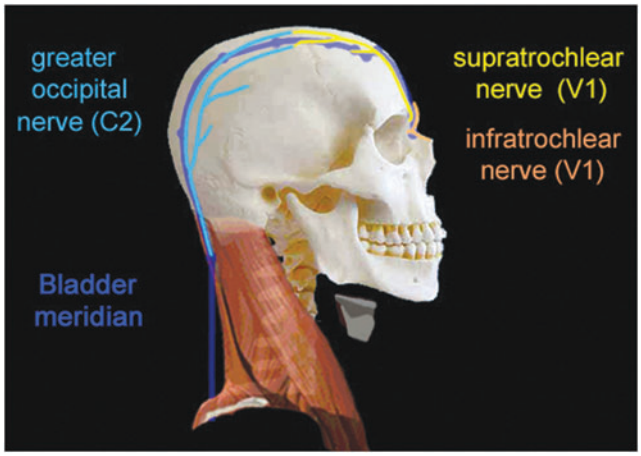

FIG. 6. Bladder Meridian neuroanatomical basis.

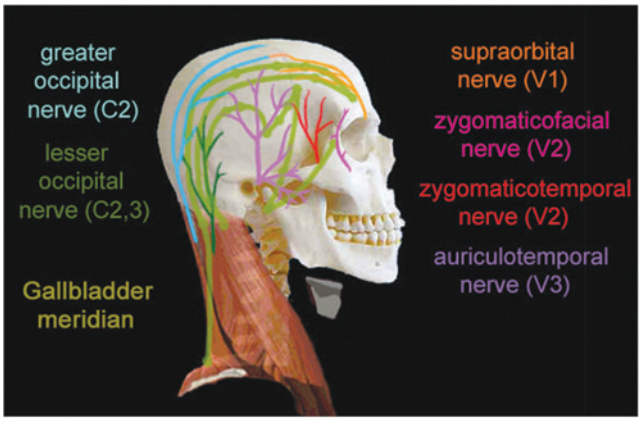

FIG. 7. Gallbladder Meridian neuroanatomical basis.

maxillary division (V2) of the trigeminal nerve anteriorly, the auriculotemporal branch of the mandibular division (V3) of the trigeminal nerve centrally, and the lesser occipital nerve posteriorly. Clemente's figure 553 shows the auriculotemporal (V3) and zygomaticotemporal (V2) nerves anastomose over the lateral head.[12] This Clemente figure also shows that anastomoses occur between the auriculotemporal and greater occipital nerves, the greater and lesser occipital nerves, and the ophthalmic division of the trigeminal nerve and the greater occipital nerve.[12]

Triple Energizer

The Triple Energizer (TE) meridian on the head is defined anteriorly by the zygomaticotemporal branch of the maxillary division (V2) of the trigeminal nerve and the auriculotemporal branch of its mandibular division (V3), while the TE meridian's posterior distribution is defined by the lesser occipital and great auricular nerves (Fig. 8). Gray documents that the great auricular and lesser occipital nerves anastomose.[7] Clemente's Figure 553 shows that the auriculotemporal and zygomaticotemporal nerves anastomose.[12] Given all the other anastomoses of anatomically adjacent nerves of the head and neck, it is likely that the lesser occipital and auriculotemporal nerves anastomose. Recall that, as previously outlined, the lesser occipital nerve anastomoses with the greater occipital nerve, which, in turn, anastomoses with the auriculotemporal nerve; this provides an alternative anatomical route that could allow physiologic connection of the lesser occipital and auriculotemporal nerves.

Stomach Meridian

The Stomach meridian in the anterior head region is defined by the infraorbital branch of the maxillary division (V2) and the mental branch of the mandibular division (V3) of the trigeminal nerve (Fig. 4), while, over the lateral head region, the buccal nerve and auriculotemporal branches of the mandibular division (V3) of the trigeminal nerve correspond well to the Stomach meridian distribution there (Fig. 9). The facial nerve (CNVII) distribution also has substantial overlap in distribution with the Stomach meridian over the lateral face. Gray documents that the temporal branches of the facial nerve anastomose with the zygomaticotemporal and auriculotemporal nerves.[7] The Stomach meridian distribution over the lateral neck is defined by the transverse cervical and supraclavicular nerves, as shown in Figure 9.

Small Intestine

The Small Intestine meridian distribution in the head and neck region is defined by the facial nerve anteriorly and the great auricular nerve posteriorly (Fig. 10). Gray documents that the great auricular nerve and facial nerve anastomose as the facial nerve exits the stylomastoid foramen.[7] The Small Intestine meridian in the neck also is anatomically proximate to the spinal accessory nerve.

Large Intestine

The Large Intestine meridian distribution on the face is defined by the infraorbital branch of the maxillary division (V2) of the trigeminal nerve (Fig. 11). Its distribution over

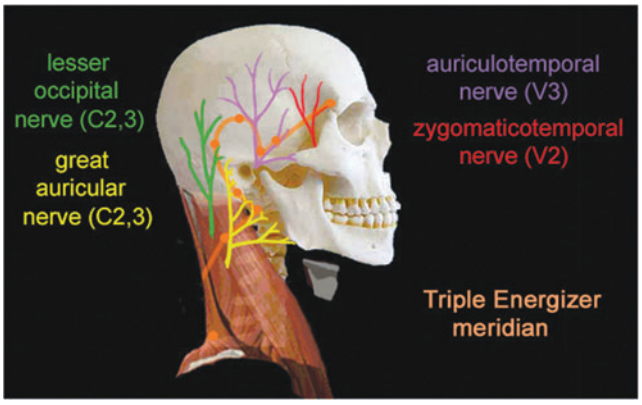

FIG. 8. Triple Energizer Meridian neuroanatomical basis.

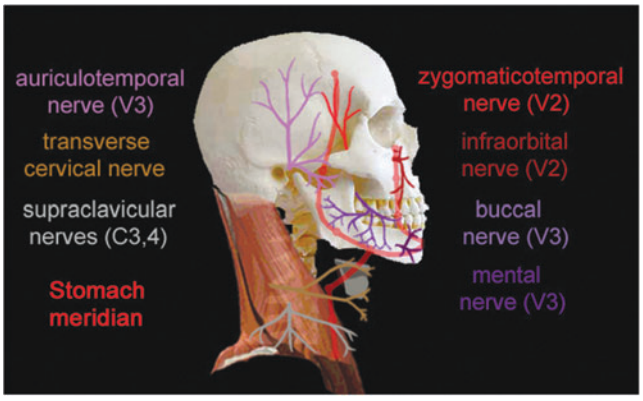

FIG. 9. Stomach Meridian neuroanatomical basis.

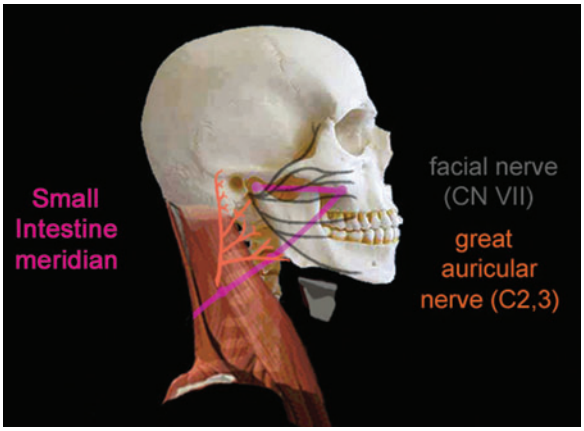

FIG. 10. Small Intestine Meridian neuroanatomical basis.

the neck is defined by the transverse cervical nerve superiorly and the supraclavicular nerves inferiorly.

DISCUSSION

In an anterior view of the head, the Stomach, Gallbladder, and Bladder Principal meridians course directly over the skull foramen where cranial nerves exit with the Gallbladder and Bladder meridians following the distributions of the nerves exiting those foramen (Figs. 4 and 5). It is highly unlikely that this is just a coincidence for all three of these meridians. The correspondences of the Principal meridians with the peripheral and cranial nerves of the head and neck derive from the extensive anastomoses of anatomically adjacent nerves there.[11,12] This includes anastomoses between the cranial nerves, between peripheral nerves derived from the cervical nerve roots, and between cranial nerves and those peripheral nerves.

The sternocleidomastoid and upper trapezius muscles are embryologically the most anterior ectodermal–derived structures in the neck and mark the anterior border of Yang/sympathetic/ectodermal innervation there. Note that all but one of the seven Yin/parasympathetic/endodermal Principal meridians traverse the anterior/ parasympathetic surface of the body below the level of the clavicles. The exception is the Conception Vessel meridian that ascends anteriorly in the midline of the neck and mandible regions (both branchial-arch derivatives) to the stomatodeum.

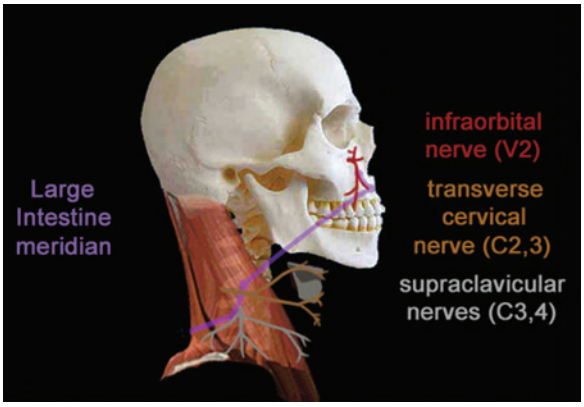

FIG. 11. Large Intestine Meridian neuroanatomical basis.

The correspondence of the Classical acupuncture points to peripheral nerves or their branches is similar to the findings for the trunk, likely deriving from the rostral fold of the embryo in the third week along with lateral folding of the branchial arches.

A neuroanatomical basis for the acupuncture meridians provides an explanation of why TCM has no representation of the nervous system despite describing all the other organs. That is, the meridians are the representation of the nervous system. The peripheral neurovascular bundles literally validate the TCM concept that Blood and Qi (energy) flow in the meridians.

A neuroanatomical basis for the Principal meridians provides the only plausible mechanism of how acupuncture styles that utilize subcutaneous needling (Japanese style) could produce physiologic effects, or how acupuncture subsystems, such as auricular or scalp acupuncture, could work. Stimulation of a location anywhere on the dermatomal-, myotomal-, and/or peripheral-nerve distribution that corresponds to a meridian would produce clinical effects of the acupuncture points in that location (whether a cutaneous nerve branch or a deeper major nerve trunk was stimulated). This will have implications for acupuncture research, and particularly for what will constitute appropriate placement and method of placebo stimulation.

The ~5000-year-old TCM tradition as described in the *Nei Jing* more than 2000 years ago provides a wealth of information on the use of acupuncture to treat physical, psychologic, and spiritual maladies.[2] The present study, by demonstrating an actual anatomic basis for the acupuncture meridians through embryologic and adult anatomic analyses, may literally serve as a neuroanatomic basis to allow translation of 2000+-year-old concepts into modern anatomical and physiologic terms. This, in turn, would allow ~5000 years of clinical experience in using endogenous mechanisms to treat and potentially reverse disease processes to be utilized in contemporary clinical practice. The potential of these findings to reduce and possibly prevent human suffering as well as providing new, cost-effective methods of health care is enormous.

CONCLUSIONS

Examination of the neuroembryologic development of the head and neck region serves to reveal anatomical correspondences of the cranial nerves, peripheral nerves, and acupuncture Principal meridians there.

''It is because of the twelve primary channels that people live, that disease is formed, that people are treated, and disease arises.''—*Spiritual Axis of the Nei Jing*, ~200 BC

AUTHOR DISCLOSURE STATEMENT

There are no financial interests to disclose.

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CME Quiz Questions

Article learning objectives:
After studying this article, participants should be able to identify the anatomic data that corroborates a neuroanatomic basis for the principal meridians of the head and neck; describe neuro-embryologic changes in the development of cranial and cervical spinal nerves that provide a neuroanatomic substrate for conceptualization of the principal channels of the head and neck; and discuss the importance of a neuroanatomic understanding of acupuncture channels in acupuncture research.

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Disclosure Information:
Authors have nothing to disclose.
Richard C. Niemtzow, MD, PhD, MPH, Editor-in-Chief, has nothing to disclose.

Questions:

1. Identify the ***incorrect*** statement:
   a. The earliest major written source of acupuncture practice and theory is the Huang Di Nei Jing, dated to 2nd century BC.
   b. The Nei Jing discussed circulation of blood in the body approximately 1800 years before the work of English physician William Harvey in the 17th century AD.
   c. The Nei Jing discussed the concept of circadian rhythms almost two millennia before the 18th century western scientist credited with introducing the concept Jean Jaques d'Ortous de Mairan.
   d. The Nei Jing did not discuss circulation of blood but concerned itself instead primarily with esoteric topics which the discussants in the text regard as unrelated to the natural world.
   e. The authors propose that a neuroanatomic basis for the Principle acupuncture channels provides a plausible mechanism for the fact that light cutaneous needling such as in 'Japanese style' acupuncture is able to produce physiologic effects.

2. Identify the ***incorrect*** statement:
   a. Microneurographic studies have demonstrated somatotopic organization of nerve fibers within the median and common peroneal nerves.
   b. The sympathetic autonomic nervous system distribution has been shown to parallel that of the peripheral nerves via its contribution to spinal nerves.
   c. The current knowledge of autonomic nervous system and spinal nerve physiology provides an explanation for the mechanism by which stimulation of a region on the cutaneous and subcutaneous tissues of the body, such as in acupuncture, can selectively affect autonomic nervous system and organ function.
   d. Neurophysiologic studies to date have failed to shed light on the phenomenon of acupuncture's apparent effect on body physiology.
   e. The authors propose that a neuroanatomic basis for the principle acupuncture channels provides the most plausible mechanism to explain how acupuncture subsystems such as auricular or scalp acupuncture work.

3. Identify the ***incorrect*** statement:
   a. The midline development of the embryo from the primitive node to the philtrum ending at the primitive mouth accurately defines the course of the Governor Vessel channel described in acupuncture theory.
   b. The region described in acupuncture theory as the Conception channel forms embryologically by eight weeks extending from the perineal body and then ascending ventrally in the midline where the lateral folds meet.
   c. Embryological development demonstrates the formation of the area identified in acupuncture theory as the Du / Governor channel on the ventral surface of the body.
   d. Embryological development demonstrates the formation of the area identified in acupuncture theory as the Du / Governor channel on the dorsal surface of the body.
   e. According to the neuroanatomical understanding of acupuncture channels presented by the authors, stimulation of either a cutaneous nerve branch or a deep major nerve trunk can both produce the clinical effects of acupuncture points in those locations and is dependent primarily on their dermatomal, myotomal and peripheral nerve distribution.

4. Identify the ***incorrect*** statement:
   a. Superimposition of the neuroanatomical pathways and the surface pathways of acupuncture channels is used as a method of inquiry and study by the authors of this paper.
   b. On a model of the human skull and neural foramen, superimposition of the branches of the trigeminal nerve with distributions of the Principle channels demonstrate specific areas of overlap and correlation.
   c. The Bladder channel over the frontal region of the skull overlaps the distribution of the vagal nerve.
   d. The Bladder channel over the frontal region of the skull overlaps the distribution of the infratrochlear and supratrochlear branches of the first division (V1) of the trigeminal nerve.
   e. According to the neuroanatomical understanding of acupuncture channels presented by the authors, stimulation of a location anywhere on the dermatomal, myotomal, and/or peripheral nerve distribution that corresponds to a channel would produce clinical effects of the acupuncture points in that location.

5. Identify the ***incorrect*** statement:
   a. The authors postulate that a neuroanatomic basis for the acupuncture meridians provides an explanation of why TCM has no representation of the nervous system despite describing all the other organs.
   b. This article proposes that modern neuroanatomical research establishes the existence of Qi.
   c. The authors state that peripheral neurovascular bundles are a modern validation of the concept discussed in the Nei Jing that the acupuncture channels convey Qi and blood.
   d. The authors propose that a neuroanatomic understanding of acupuncture channels has important implications for acupuncture research, particularly for what will constitute appropriate placebo needle placement.

e. A neuroanatomic understanding of acupuncture channels supported by embryologic and adult anatomic analyses may provide a foundation for a modern understanding of the 5,000 year old traditional Chinese medicine practice of treating physical and psychological maladies with acupuncture.

Continuing Medical Education – Journal Based CME Objectives:
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