



Review Article

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Sympathetic Innervation of the Small Intestine and Colon: The Superior Mesenteric Ganglion and the Chinese Syndromes of Deficiency of Blood in the Intestine, of Coldness in the Intestine Amongst Indications of Spleen 6 (Spl6)



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Introduction

Is it possible to explain the esoteric Chinese syndromes of Empty Blood and Coldness in internal organs by modern physiology? We examine the vascular properties of the superior mesenteric artery and the sympathetic perivascular innervation of the small intestine (SI) and Colon. We focus on vasoconstriction of SI and Colon. We examine if some indications of Spleen 6 (Spl 6) are compatible with modern neurophysiology.

Superior Mesenteric Artery Syndrome

External compression of the jejunum between aorta and the superior mesenteric artery is attributed to the involution of adipose tissue between both arteries, closing in on the passage gap for the small intestine. The diagnosis is difficult, being a process of elimination of multiple differential conditions. The complaints of the patient comprise digestive problems like postprandial distension, malabsorption, stagnation of food in the small intestine, bacterial overgrowth, stomach complaints as reflux through the pylorus, esophageal reflux etc. This condition is aggravated at night, may depend on posture, is subject to spastic pain due to a varying degree of subobstruction and the nature of the pain is described as stabbing. It is a very rare anatomical condition, present during quick adolescent growth, absence or disappearance of visceral- or retroabdominal fat or emaciation at older age. The Chinese syndrome of chronic Deficiency of Blood in the Intestine presents the same complaints, but on the contrary is a very common condition. It does not result from external obstruction but is due to vasoconstrictive hyperactivity of the superior mesenteric ganglion. In traditional Chinese medicine (TCM) avascular pain in general was described

as stagnation of Blood, stabbing in nature, very localized and being aggravated during night or sleep time.

Ganglion Mesentericum Superius

This ganglion consists of postganglionic neurons of the sympathetic innervation of the SI and proximal colon. The efferents accompany the upper mesenteric artery, irrigating, the distal half of the duodenum, the jejunum, the ileum and the proximal two thirds of the colon. Activation of its perivascular efferents provoke vasoconstriction of the terminal arterial arborizations in the aforementioned vascular beds. It mimics the anoxic symptoms of a superior mesenteric artery syndrome.

The Small Intestine

The small intestine (SI) measures 3 to 5 meters and is irrigated by arterial vasa recta, building arterial arcades. The mucosa surface area can go up to 30 m², which gives a considerable irrigation volume to which the proximal two thirds of the colon should be added. The surface area of the SI is multiplied by the villi projecting in huge numbers into the lumen, each containing a capillary extension. Vasoconstriction of the terminal arborizations of the superior mesenteric artery dries out the mucosa of the small intestine and the proximal colon, in spite of vagal secretomotor activity. The vagus becomes ineffective due to insufficient liquid supply. Constipation is the clinical result of intestinal dryness. Digestive peristalsis, interdigestive migratory motor complexes, small intestine bacterial overgrowth, inflammatory bowel disease and spastic irritable colon will be discussed in later chapters. Bacterial

overgrowth in the distal ileum can give rise to both transit problems: constipation as well as diarrhea.

Deficiency of Blood in the SI (TCM)

Vasoconstriction in the superior mesenteric artery explains the Chinese syndrome of Deficiency of Blood in the Intestine [1]. Constipation is its hallmark. The syndrome was described in the first century BC. Visceral alerting reflex: Under the heading of defensive responses, the periaqueductal grey (PAG) contains the programming and coordination of behavioural stress responses. These reflexes involve passive- and active coping of respectively freeze- and fight-flight archetypical expression. Somatosensory- somatomotor- cutaneous sympathetic- and visceromotor reflexes are coordinated simultaneously. The visceromotor component involves vasoconstriction of visceral vascular beds and vasodilatation of somatomotor vascular beds. The integration by the PAG constitutes the generation of appropriate behavioural responses in a stress related adaptation.

Periaqueductal Grey (PAG)

In a pain study, influence of Spl6 was demonstrated on beta-endorphine levels in the PAG [4]. This might be important for the role of Spl6 in the aforementioned visceral alert.

Avoidable- or Escapable Stress Versus Unavoidable- or Inescapable Stress

Stress coping mechanisms were first described by R.Bandler & K.Keay (Sydney, Australia) [5] and reviewed by R.Dampney (Sydney, Australia) [6]. They are situated in the effector site of the PAG. The relationship between the dorsolateral column and avoidable- or escapable stress has been established. Evenso the relationship between the ventrolateral column and unavoidable- or inescapable stress has been confirmed. Activation of the ventrolateral column with electroacupuncture has been demonstrated by J.Longhurst (Irvine, California). We postulate as a further research prospect to scrutinize the relationship of avoidable- or escapable stress with constipation as clinical symptom in the visceral alert on the basis of intestinal vasoconstriction. In terms of TCM, this is a Liver problem (deficiency of Blood) with constipation. We also postulate a relationship between unavoidable- or inescapable stress and loose stools or watery diarrhea on the basis of central inhibition of intestinal vasoconstriction. In terms of TCM, this is a Spleen problem (deficiency of Qi) with loose stools.

Influence of Acupuncture on the Colon

Amongst acupoints with therapeutic effect on quality of life improvement in irritable colon figures also Spl6 [7]. A meta-analysis performed in 2012 shows favourable significance of acupuncture in irritable colon [8]. An acupoint group with Pc6 treated equally irritable colon with constipation [9] as with diarrhea [10]. Within the framework of this article on TCM diagnostics, our interest goes to constipation from Deficiency of Blood. Chinese medicine however stresses the restoration of an equilibrium. In the PAG the dorsolateral column and the

ventrolateral column are interconnected. We postulate on the possibility that behavioural responses may shift swiftly when sudden resolution of a problem is realized or a shift from an escapable- to inescapable situation occur, or vice versa.

Discussion: In a future article we will study also the dorsal vagal complex to pinpoint the mechanism of equilibrium.

Influence of Acupuncture on Constipation

Another meta-analysis, also performed in 2012 showed favourable effect of acupuncture in constipation [11] and yet another one from 2016 equally presented favourable results in post-stroke constipation [12].

Coldness in the SI (TCM)

Here we present Coldness in the SI due to deficiency of Blood in the SI, standing in relation to constipation which is due to visceral vasoconstriction as the clinical symptom in avoidable- or escapable stress. We believe this syndrome to be very common.

Discussion

In TCM Coldness in the SI refers mainly to diarrhea of the watery type, due to deficiency of Yang. This can be explained by hyperactivity of vagal vasomotor innervation and, possibly, a sympathetic withdrawal on top of this. This results in increased peristaltic activity and shortening of transit time on the one hand, and in vagal secretomotor activity, which results in hypersecretion on the other hand. We will discuss parasympathetic modulation elsewhere.

Caloric Content of Blood (TCM)

Not only does blood deliver nutrients and oxygen to the tissular target organs, but also heat contained in the blood. The internal organs are warmed up by blood irrigation. During digestion, heat distribution by vasodilatation within stomach and intestines favours the action of smooth muscles. Vasoconstriction blocks this thermal support. This property of blood has been described in Chinese physiology in the first century BC as a syndrome of Coldness of the Intestines (SI and Colon).

Deficiency Heat (TCM)

The heat content of blood that normally should be distributed to the SI and the proximal two thirds of the colon is diverted by amplified vasoconstriction of the tributaries of the superior mesenteric artery. The total arterial capacity is considerable. The redistribution of the caloric content is called in Chinese physiology: Heat by deficiency. The underlying physiology may be explained by the Western concept of visceral alert.

Heat in the Blood (TCM)

Heat in the Blood is a general Chinese concept. The above example is defined as deficiency Heat because it is redistributed and derived from intestinal vasoconstriction by the visceral alerting reflex. There are other differential sources of Heat in the Blood.

Discussion

For further study in detailed physiology of heat production, -distribution, -conservation and -dissipation we refer to the chapters concerning HARR, the adrenal gland, brown adipose tissue and thermoregulation in general.

Segmental Innervation of the Superior Mesenteric Ganglion

The segmental levels innervating the superior mesenteric ganglion are situated in dorsal levels D10 & D11. Efferents of segmental level D12 are shared with the inferior mesenteric ganglion. The preganglionic neurons are harboured in the intermediolateral column. Three segmental levels account for the sympathetic innervation of the SI and the proximal colon. Descending activation or inhibition is ultimately derived from the periaqueductal grey amongst other more distal centers. The direct activation depends on the noradrenergic collection called A5 in the pons, situated ventrally to the facial nucleus.

Influence of Acupuncture on the Propulsion in the Small Intestine

In a model of postoperative colon anastomosis, propulsion of the small intestine was measured. St36 en Spl6 restored the function of interstitial cells of Cajal, accelerating transit of the small intestine [13]. Radio-opaque small rings contained in a capsule are called Sitz-markers. They can measure transit time of ileum or colon in patients with chronic constipation. In TCM constipation would be compatible with Deficiency of Blood. A group of acupuncture points, Spl6 amongst them, accelerated small intestine transit in postoperative ileus [14]. However postoperative ileus depends on vagal paralysis. We have as yet no data on the influence of Spl6 in chronic constipation with Sitz-markers. The paradigm is available for future prospects. However, heterotopic points in the lower limb have been demonstrated to improve jejunal motility through cholinergic receptors (M3) [15].

Discussion on the Afferent-Sensory Versus Efferent-Effector Segmental Influence of Acupuncture

Rodents are favoured experimental animals because they are small enough to be easily handled, and because they show high availability through abundant breeding. However segmental influence is confusing because they have 7 cervical-, 13 thoracic- and 6 lumbar vertebrae. Needling the receptive field of Spl6 has been demonstrated to be distributed afferently to sensory entry levels 3-6 of the rat [16]. In this article we follow the influence of acupuncture through their efferent preganglionic segments innervating the prevertebral ganglia of the orthosympathetic nervous system on their way to reach their respective effector organs. In this case segmental levels D10-12 are accountable for the superior mesenteric ganglion in humans. We are interested in their suprasedgmental activation which is independent from the entrance level of stimulation. Central modulation does

respond to peripheral input but the segmental levels are irrelevant since the efferent levels determine the effect on the respective effector organs. However a specific acupoint stimulation might be concentrated on a prevertebral ganglion but they are by no means totally exclusive. We suggest a fictional proportional distribution over the three prevertebral ganglia in the range of 60% on the main ganglion, 30% and 15% on the two remaining, each time plus/minus 5%. For Pc6 we would suggest 60% on the coeliac ganglion, 30% on the superior mesenteric ganglion and 15% on the inferior mesenteric ganglion. For Spl6 we suggest 60% influence on the superior mesenteric ganglion, 30% on the inferior mesenteric ganglion and 15% on the coeliac ganglion.

Doppler Flowmetry Of Superior Mesenteric Artery

Significant Doppler flowmetry of the superior mesenteric artery has been demonstrated in relation to needling of St36 [17,18] but to our knowledge, not yet in relation to Spl6. Differentiation of points has been demonstrated since Liv3 does not show significant flowmetry on the superior mesenteric artery. In an endotoxine model of inflammation provoking COPD in rats, St37 en Lu5 have been shown to decrease microscopic flow in the superior mesenteric artery [19].

Conclusion

According P.Deadman, Spl6 treats also constipation due to Deficiency of Blood. This syndrome is compatible with the vasoconstrictive action on small intestine and proximal colon, due to hyperactivity of the efferent innervation by the superior mesenteric ganglion. Visceral alert mobilizes this blood reserve to feed the muscular compartment in stressful adaptive behaviour. We suspect the lateral PAG to integrate responses during escapable- or avoidable stress, but correlation with constipation has yet to be demonstrated. The pontine noradrenergic group A5 activates the preganglionic neurons in the intermediate horn on levels D10-D12. Therefore we postulate for Spl6 a central inhibition of vasoconstrictive preganglionic neurons in the intermediolateral column innervating the superior mesenteric ganglion. In a next lecture we will compare three acupoints Pericardium 6 (Pc6), Spleen 6 (Spl6) and Kidney 6 (Ki6). We will discuss common indications and differential symptoms in an integrated manner.

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