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Review

Acupuncture for functional gastrointestinal disorders

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Functional gastrointestinal (GI) symptoms are common in the general population. Especially, motor dysfunction of the GI tract and visceral hypersensitivity are important. Acupuncture has been used to treat GI symptoms in China for thousands of years. It is conceivable that acupuncture may be effective in patients with functional GI disorders because it has been shown to alter acid secretion, GI motility, and visceral pain. Acupuncture at the lower limbs (ST-36) causes muscle contractions via the somatoparasympathetic pathway, while at the upper abdomen (CV-12) it causes muscle relaxation via the somatosympathetic pathway. In some patients with gastroesophageal reflux disease (GERD) and functional dyspepsia (FD), peristalsis and gastric motility are impaired. The stimulatory effects of acupuncture at ST-36 on GI motility may be beneficial to patients with GERD or FD, as well as to those with constipation-predominant irritable bowel syndrome (IBS), who show delayed colonic transit. In contrast, the inhibitory effects of acupuncture at CV-12 on GI motility may be beneficial to patients with diarrhea-predominant IBS, because enhanced colonic motility and accelerated colonic transit are reported in such patients. Acupuncture at CV-12 may inhibit gastric acid secretion via the somatosympathetic pathway. Thus, acupuncture may be beneficial to GERD patients. The antiemetic effects of acupuncture at PC-6 (wrist) may be beneficial to patients with FD, whereas the antinociceptive effects of acupuncture at PC-6 and ST-36 may be beneficial to patients with visceral hypersensitivity. In the future, it is expected that acupuncture will be used in the treatment of patients with functional GI disorders.

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Introduction

Functional gastrointestinal (GI) symptoms are common in the general population, with a reported prevalence of 25%–40%. Functional GI symptoms, which are responsible for up to 40% of office consultations with gastroenterologists in the United States, are multifactorial disorders in which the pathophysiological mechanisms are variably combined in different patients. In particular, motor dysfunction of the GI tract and visceral hypersensitivity are considered to be important.

Acupuncture has been used to treat GI symptoms in China for thousands of years. However, the mechanisms behind the beneficial effects of acupuncture remain mysterious. Acupuncture may be effective in patients with functional GI disorders because acupuncture has been shown to alter acid secretion, GI motility, and visceral pain. Here, the effects of acupuncture on GI function and its mechanisms are reviewed and the efficacy of acupuncture in treating functional GI disorders is evaluated.

Acupuncture treatment

Effects of somatic afferent nerve stimulation on GI function

Somatic afferents from skin and muscle are involved in the control of various autonomic functions. In 1913, Lehman[1] reported that electrical stimulation of the central part of the sciatic nerve inhibited small intestinal motility in anesthetized dogs and that the splanchnic nerve was responsible for mediating the inhibitory response. In 1927, Ruhmann[2] reported that mechanical

and thermal stimulation of the abdominal skin affects gastric motility in humans. In 1969, Jansson[3] reported that electrical stimulation of the hind limb stimulates gastric motility via somatic afferents in anesthetized cats. In 1975, Kehl[4] observed changes in jejunal motility after abdominal skin stimulation in nonanesthetized dogs and suggested that these changes were due to somatoautonomic reflex responses.

More details of the neural mechanisms of the cutaneo-GI motility reflexes were studied in anesthetized rats during 1975–1980. The sympathetic efferent nerve activity innervating the stomach is responsible for the inhibitory cutaneogastric reflex.[5–7] Sensory stimulation of the abdominal skin of rats by pinching inhibits gastric motility by increasing gastric sympathetic efferent nerve activity. In contrast, pinching of other skin areas, such as a hind paw, can enhance gastric motility by exciting gastric vagal efferent nerve activity.[7]

In healthy humans, transcutaneous electrical nerve stimulation (TENS) resulted in a significant reduction in antral motility when applied to the hand and abdomen. This reduction was not associated with a change in pulse, blood pressure, or circulating catecholamine levels. As there was a similarity in the responses to TENS applied to the hand and abdomen, it was suggested that the induced somatovisceral responses are relayed predominantly at the cerebral level.[8]

In human patients, TENS influences the function of the GI tract. It causes relaxation of the lower esophageal sphincter (LES)[9,10] and a decrease of Oddi pressure in the basal sphincter,[11] as well as an increase in tolerance to gastric and duodenal distension.[12]

Although the physiological significance of cutaneo-GI reflexes is not yet clear, thermal stimulation of the abdominal skin is often used for clinical treatment of GI malfunction. There are many nonnociceptive unmyelinated (group IV) fibers in the cutaneous afferents; in particular, those arising from thermoreceptors belong to this group.[6] The precise mechanism mediating cutaneo-GI reflexes remains unknown.

History of acupuncture

A series of investigations carried out on somatoautonomic reflexes have provided good evidence of the importance of cutaneous input in autonomic control of GI motility.[1–3,5–7] The acupuncture procedure involves the insertion of thin needles into the skin and underlying muscle layer. In traditional acupuncture, the needles are twisted right and left at 0.5- to 1-s intervals. More recently, acupuncture needles are stimulated by electricity at various frequencies (1–100 Hz). These procedures may stimulate the somatic afferent nerves innervating the skin and muscles of the body.

Acupuncture is an ancient form of traditional Chinese medicine that can be traced back for 5000 years. The first record of acupuncture is found in the 4700-year-old *Huang Di Nei Jing* (Yellow Emperor's Classic of Internal Medicine),[13,14] which is believed to be the oldest medical textbook in the world. As the basis for acupuncture, it was theorized that the body had an energy force known as qi (pronounced "chee") running through it. According to this theory, a person's health is influenced by the flow of qi in the body, in combination with the universal forces of yin and yang. If the flow of qi is insufficient, unbalanced, or interrupted, yin and yang become unbalanced and illness may occur. Yin and yang are opposite forces, that when balanced, work together in harmony. Yin, signified by female attributes (passive, dark, cold, and moist), moves medially, and is deficient in yang. Yang, signified by male attributes (light, active, warm, and dry), moves laterally and is deficient in yin. Acupuncture is believed to restore the balance of yin and yang.

Acupuncture loci, or "acupoints," are the skin needling points used for acupuncture treatment. Similar to the concept of a trigger point, which produces pain in an adjacent or remote area, acupoints are thought to be specific points that reflect visceral conditions and organs.[15] In humans, more than 300 acupoints (most of which, known as "meridian points," are located along meridians) are used for acupuncture treatment. Despite the fact that specific acupoints are used for treating specific symptoms or diseases, it is not fully understood how their specificity applies or how the needling at acupoints works.

When acupuncture was first presented to the American public in 1972, a great deal of interest was generated in this new—yet ancient—practice. Although there is clinical support for its effectiveness, acupuncture has not been well developed in the United States in the last few decades, perhaps because of the mysterious, unexplainable mechanisms of acupuncture.

Pathogenesis of functional GI disorders

Functional GI disorders include gastroesophageal reflux disease (GERD), functional dyspepsia (FD), and irritable bowel syndrome (IBS). The symptoms of these disorders, which are multifactorial, are common in the general population.

Gastroesophageal reflux disease

Acid secretion, motor dysfunction of the esophagus and stomach, and hypersensitivity to acid are important in patients with GERD.[16,17] Acid is the major cause of symptoms and anatomical lesions. It is well accepted

that the frequency of GERD symptoms is related to the degree of esophageal acid exposure.[18,19] Acid reflux time is significantly correlated with the severity of endoscopic esophagitis.[20] In addition, pepsin and bile acids are noxious to the esophageal mucosa, but their injurious action is highly dependent on the presence of acid. Motor dysfunction of the LES and, possibly, the proximal stomach is a major cause of increases in the number of reflux episodes. Alterations in primary and secondary peristalsis may contribute to the increased esophageal acid exposure by delaying clearance. Patients with GERD often have delayed acid clearance from the esophageal body[21,22] and are often more sensitive to acid reflux than healthy subjects. In some patients, this esophageal hypersensitivity also extends to mechanical stimuli, which becomes the main pathophysiological problem. When acid was infused into the esophagus of control subjects and GERD patients, only 15% of the controls reported heartburn during acid infusion, while 88% of GERD patients had heartburn during acid infusion.[23]

Functional dyspepsia

FD symptoms include chronic or recurrent pain or discomfort centered in the upper abdomen, not due to peptic ulcer disease, that is considered to originate from the upper GI tract. FD is a symptom complex characterized by postprandial upper abdominal discomfort or pain, early satiety, nausea, vomiting, abdominal distension, bloating, and anorexia in the absence of organic disease. GI motor abnormalities, altered visceral sensation, and psychosocial factors have all been identified as major pathophysiological mechanisms in FD.

Approximately 50% of patients with FD have motor disorders, such as antral hypomotility, impaired accommodation reflex, and gastric dysrhythmias.[24] Delayed gastric emptying has been reported to occur in between 30% and 50% of patients with FD. The presence of antral hypomotility has been shown by manometric techniques. Antral hypomotility is sometimes accompanied by disordered intestinal motility. Impaired gastric accommodation to a meal has been found in 40% of patients with FD.[25]

Increased perception of physiological or minor noxious stimuli has been demonstrated in patients with FD in both the fasting and postprandial states. Compared with healthy controls, patients with FD are hypersensitive to isobaric or isovolumetric balloon distension of the proximal stomach.[24]

Irritable bowel syndrome

IBS is one of the most common GI conditions encountered by general practitioners. It accounts for a great deal of the workload of gastroenterologists in secondary care. Research to date indicates that several factors contribute to the development of IBS. Disturbed GI motility, altered visceral perception, and psychosocial factors are regarded as the most important mechanisms, which interact to cause the development of IBS.[26]

As colonic transit in the proximal colon is significantly accelerated in diarrhea-predominant IBS patients, accelerated transit through the proximal colon is a factor in the pathophysiology of diarrhea-predominant IBS.[27] In contrast, fewer fast colonic propagated contractions characterize patients with constipation-predominant IBS.[28,29]

The threshold of reported pain is below the normal range in 50%–70% of IBS patients, who are more likely than controls to notice intestinal contractions and gas. Their pain thresholds are correlated with the amount of clinical pain they experience.[30]

A third to a half of patients with IBS are depressed or anxious, or they report that their symptoms are worsened by stress or they have a psychiatric diagnosis. This suggests that psychological distress may be an etiologic factor common to patients with IBS.[31]

Effects of acupuncture on GI function

Acupuncture for treating GI symptoms

Acupuncture has been used to treat GI symptoms, including acute and chronic gastroenteritis, diarrhea, constipation, vomiting, nausea, and gastroduodenal ulcer.[32–34] The most commonly used acupuncture points in treating GI symptoms are the Zusanli point of the lower limb (stomach-36; ST-36) and the Neiguan point at the wrist (pericardium-6; PC-6).

ST-36 is located at the proximal one-fifth of the craniolateral surface of the rear leg, distal to the head of the tibia in a depression between the muscles of the cranial tibia and the long digital extensor. PC-6 is located in the groove caudal to the flexor carpi radialis and cranial to the superficial digital flexor muscles (Fig. 1). In general, acupuncture treatment is performed once or twice a week for several weeks to treat chronic GI symptoms.[32–36]

Studies published in the Chinese literature have reported improvements of GI symptoms with acupuncture.[35] However, the mechanism of the beneficial effects of acupuncture remains to be investigated.

ST-36 and PC-6 are the common points for the treatment of gastric symptoms such as nausea and vomiting, suggesting that acupuncture at ST-36 and PC-6 may stimulate GI motility in humans. In contrast, acupuncture on the abdomen (CV-12) is used to treat patients with abdominal pain,[33,36] suggesting that acupuncture at

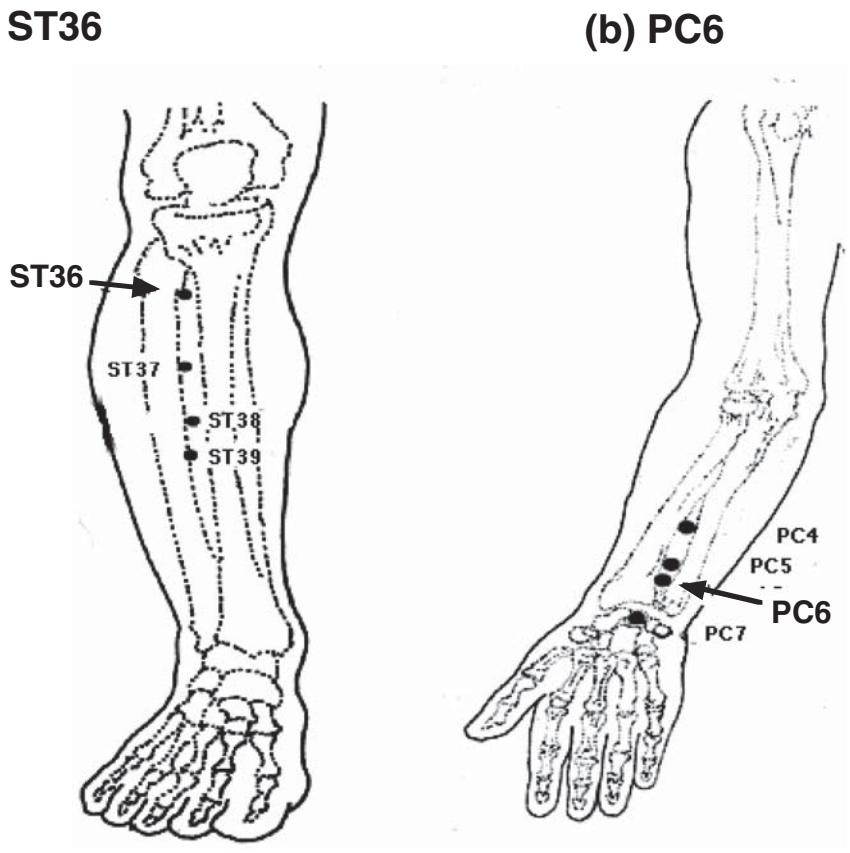

Fig. 1. The locations of acupoints ST-36 (**a**) and PC-6 (**b**) in humans. ST-36 is located at the proximal one-fifth of the craniolateral surface of the leg, distal to the head of the tibia in a depression between the muscles of the cranial tibia and the long digital extensor (**a**). PC-6 is located in the groove caudal to the flexor carpi radialis and cranial to the superficial digital flexor muscles (**b**)

CV-12 may inhibit GI motility and/or reduce spasming of GI muscles.

Effects of acupuncture on acid secretion

It appears that the impact of acupuncture on acid secretion is variable and depends on various factors, including anesthesia, species, acupoints used, and the acupuncture procedure.

Electrical acupuncture (EA) stimulation at the hind limb (ST-36) increases gastric acid secretion in rats, and sectioning of the sciatic nerve and vagotomy block the acupuncture-induced acid secretion.[37] This suggests that the acupuncture effect involves a somatic afferent–visceral reflex mechanism; somatic nerves function as the afferent pathway, and the vagus nerve to the stomach functions as the efferent pathway.

In contrast, an inhibitory effect of acupuncture on acid secretion is reported in conscious dogs. EA at the wrist (PC6) and at ST-36 increases gastric secretion of bicarbonate and sodium and decreases gastric secretion of acid in conscious dogs in the interdigestive state. The effects of acupuncture are completely blocked by either a local anesthetic agent or an anticholinergic agent,[38] suggesting that the gastric secretion induced by acupuncture is mediated by a somatic afferent–visceral reflex mechanism via muscarinic receptors. Other studies have demonstrated that EA at B-20 (back), ST-36, and PC-6 inhibits acid secretion in conscious dogs. EA increases plasma somatostatin, vasoactive intestinal peptide (VIP), and beta-endorphin, and decreases plasma gastrin. Naloxone reverses the EA-induced inhibition of acid secretion. Based on these results, the inhibition by EA of acid output is mediated by the release of somatostatin, VIP, and opioids.[39]

In humans, there is accumulated evidence of an inhibitory effect of acupuncture on gastric acid secretion. The mean basal acid output (BAO) and the mean maximal acid output (MAO) in the duodenal ulcer group are significantly reduced by acupuncture at PC-6.[40]

When compared with placebo acupuncture, EA at ST-36 decreases BAO as well as sham feeding-stimulated acid output in healthy men. The inhibitory effect of acupuncture on sham feeding-stimulated acid output is prevented by a prior naloxone injection, suggesting that the antisecretory effect of EA is mediated through opioid pathways.[41] EA at B-21 (back) and ST-36 also reduces gastric acid secretion in healthy volunteers.[42]

Effects of acupuncture on GI motility

Sato et al.[43] studied the effects of acupuncture stimulation of the various segmental areas on gastric motility in anesthetized rats.[43] Gastric motility was inhibited by acupuncture applied to the abdomen, and was often excited when the limbs were stimulated. The inhibitory gastric response to abdominal stimulation was abolished by severance of the sympathetic nerve branches to the stomach. In contrast, the excitatory gastric response to hind limb stimulation was abolished by severance of the bilateral vagi.[43]

Other studies have demonstrated that gastric relaxation induced by acupuncture on the abdomen in anesthetized rats is abolished by propranolol, splanchnic ganglionectomy, and spinal cord transection, but not by phentolamine or truncal vagotomy. Because acupuncture-induced gastric relaxation is inhibited by spinomedullary transection but not by pontomedullary transection, the brain stem may be the reflex center of acupuncture-induced gastric relaxation. Acupuncture increases c-Fos expression at the rostral ventrolateral medulla (RVLM) of the brain stem,[44] suggesting that acupuncture on the abdomen stimulates somatic skin and muscle afferents. The sensory information is carried to the RVLM through the spinal cord. The RVLM sends efferent fibers via the intermediolateral (IML) nucleus to the celiac ganglia, which sends sympathetic postsynaptic fibers to the stomach. Released catecholamine (CA) from the sympathetic nerves stimulates the beta adrenoceptor located on the smooth muscle cells, resulting in gastric relaxation.

In a conscious rat study, acupuncture at ST-36 caused gastric contractions. Acupuncture-induced gastric contractions were abolished by atropine, hexamethonium, and vagotomy. The sensory neural inputs induced by acupuncture at ST-36 may be carried to the dorsal motor nucleus of the vagi (DMV) through the spinal cord. The efferent limb involves the vagal efferent, and released acetylcholine from the gastric myenteric plexus stimulates gastric contractions.[45]

In a conscious canine study, combined EA at ST-36 and PC-6 enhanced the gastric migrating motor complex (MMC) by reducing the length of phase I and increasing the lengths of phases II and III.[46] EA at ST-36 and PC-6 increases the regularity of gastric slow waves in both the proximal and distal stomach and accelerates gastric emptying of liquid in dogs.[47]

In humans, acupuncture at ST-36 increases the plasma pancreatic polypeptide (PP) levels.[48] As PP release is dependent on vagal activity, this supports the possibility that acupuncture at ST 36 stimulates vagal activity.

The different effects of EA between PC-6 and ST-36 on gastric myoelectrical activity have been compared in healthy humans. EA at PC-6 reduces peak dominant power (PDP), while EA at ST-36 increases PDP. Since PDP is associated with the amplitude of gastric contractions, these findings suggest that EA at these two acupoints induces either an increase or a decrease in gastric motility.[49]

EA at ST-36 accelerates colonic transit and stimulates distal colonic motility in conscious rats. The stimulatory effect of EA on distal colonic motility is mediated via the activation of the Barrington nucleus of the pons and peripheral pelvic nerves.[50]

Effects of acupuncture on emesis

Dundee and coworkers[51–53] have reported that acupuncture at PC-6 in patients who had undergone gynecological surgery provided a significant antiemetic effect on postoperative nausea and vomiting. Acupuncture at PC-6 also decreased cisplatin-associated nausea and vomiting. A clinical study has also demonstrated that EA at PC-6 significantly inhibits postoperative nausea and vomiting.[54]

EA at PC-6 reduces gastric tachyarrhythmia in vection-induced motion sickness in healthy volunteers, suggesting that EA may enhance the regularity of gastric myoelectrical activity.[55] Combined acupuncture at ST-36 and PC-6 increases the percentage of regular slow waves, resulting in the normalization of arrhythmia in healthy humans.[56]

The level of plasma arginine vasopressin is rapidly elevated in response to diverse emetic stimuli such as motion stimuli,[57] apomorphine,[58] and anticancer drugs.[59,60] Intravenous injection of vasopressin results in vomiting and retching in humans[57,61] and dogs.[62,63] A recent study showed that acupuncture at ST-36 and PC-6 attenuated symptom scores for emesis induced by vasopressin infusion in conscious dogs.[63] Acupuncture at PC-6 also attenuated retrograde peristalsis induced by vasopressin in conscious dogs. The antiemetic effect of EA was abolished by naloxone (a central and peripheral opioid receptor antagonist), but not by naloxone methiodide (a peripheral opioid antagonist),[64] suggesting that the antiemetic effect of EA is mediated via a central opioid pathway. Symptoms of motion sickness are made more severe by the administration of naloxone.[65] Thus, central opioid receptors may play a role in inhibiting the development of motion sickness.[55]

The emetic effect is mediated via the chemoreceptor trigger zone (CTZ), whereas the antiemetic effect is mediated via the vomiting center.[66–68] The CTZ is contained in the area postrema on the caudal margin of the fourth ventricle. As the area postrema has no blood brain barrier (BBB), naloxone methiodide can antagonize the emetic effect of opioid mediated via the CTZ. In contrast, the vomiting center is located deep beneath

the solitary tract of the caudal brain stem.[68] Both the emetic and antiemetic effects of opioids can be blocked by naloxone, because naloxone can cross the BBB.

The emetic effect of opioids can be blocked by methylnaltrexone (MNTX; a peripheral opioid antagonist). MNTX combined with morphine reduces apomorphine-induced emesis and blocks cisplatin-induced emesis in conscious dogs.[68]

Effects of acupuncture on visceral pain

Abdominal pain is attenuated by acupuncture at PC-6 and CV-12.[33,36] The antinociceptive effect of acupuncture has recently been demonstrated in conscious dogs. The increase in mean arterial blood pressure (MAP) caused by rectal distension was evaluated as an index of visceral pain. EA at ST-36, but not at BL-21 (back), significantly reduced the increase in MAP in response to rectal distension. The antinociceptive effect of EA at ST-36 was abolished by pretreatment with naloxone, but not by naloxone methiodide. These findings suggest that EA at ST-36 may reduce visceral pain via a central opioid pathway.[69]

It has been well demonstrated that the analgesic effect of acupuncture is mediated by an endogenous opioid pathway.[32,33] Opioid signaling plays a pervasive role in the medullospinal network that controls sympathetic tone and arterial pressure.[70] A significant portion of the inhibition of the gallbladder pressor response by EA at PC-6 is related to activation of mu- and delta-opioid receptors in the RVLM in rats.[71] EA at PC-6 inhibited the pressor response to bradykinin. The inhibitory effects of EA on blood pressure were reversed by intravenous injection of naloxone or microinjection of naloxone into the RVLM, indicating that the inhibitory effects of EA on the bradykinin-induced pressor response are dependent on the activation of opioid receptors, specifically receptors located in the RVLM.[72]

Opioid-induced antinociception is mediated by a pathway from the periaqueductal gray (PAG) to the various brain nuclei. Recent research has documented that opioids are likely to exert direct effects on PAG projection neurons through both delta- and mu-opioid receptors.[73] EA can induce the expression of opioid peptides and opioid receptors in the central nervous system (CNS).[74,75]

Functional magnetic resonance imaging (fMRI) studies have revealed that acupuncture stimulation modulates the human CNS. Acupuncture at PC-6, in comparison with sham acupuncture, selectively activates the left superior frontal gyrus, anterior cingulate gyrus, and dorsomedial nucleus of the thalamus in healthy humans.[76] The PAG and cortical areas respond to acupuncture at LI-4 (hand) with increased activity, while sham acupuncture results in reduced levels of PAG and cortical activity.[77]

Proposed mechanisms of acupuncture for functional GI disorders

GERD

Although very few studies have recognized the beneficial effect of acupuncture on GERD, acupuncture may have clinical efficacy for treatment of GERD by its stimulatory effects on GI motility and its inhibitory effects on acid secretion.

Postprandial receptive relaxation of the fundus is more prolonged in patients with GERD and is associated with a delayed emptying of the proximal stomach.[78] The rate of emptying of the proximal stomach may contribute to the extent of 24 h as well as postprandial acid exposure.[79] Alterations in primary and secondary peristalsis may contribute to the increased esophageal acid exposure by delaying clearance.[80]

The vagus nerve regulates LES relaxation and esophageal peristalsis.[81–83] Peristalsis in the striated section is directed by sequential vagal excitation arising in the brainstem.

Acupuncture at CV-12 causes relaxation of the stomach via the somatosympathetic pathway,[44] while acupuncture at ST-36 causes contraction via the somatoparasympathetic pathway in rats.[45] It is conceivable, but not yet demonstrated, that the stimulatory effects of acupuncture at ST-36 on GI motility may be beneficial in patients with GERD.

EA at ST-36 and EA at B21 (back) decrease acid secretion in healthy humans.[41,42] Acid secretion is reduced by acupuncture at PC-6 in patients with duodenal ulcer.[40] In addition, it is highly likely that acupuncture at CV-12 inhibits acid secretion via the somatosympathetic pathway. It remains unknown whether EA or acupuncture affects acid secretion in GERD patients.

TENS on the chest significantly reduces symptoms during balloon distension of the esophagus in patients with chest pain.[84] Because patients with GERD have altered esophageal perception and an abnormal afferent sensory pathway,[85] the effects of acupuncture on esophageal sensory thresholds may be an important part of the therapeutic effect.

FD

Because of the proven effects of acupuncture on modulating gastric motor activity, acupuncture may be useful in some cases of FD.

Delayed gastric emptying has been reported to occur in between 20% and 50% of patients with FD.[24] The

patients with FD sometimes show reduced activity of the vagus.[86,87] A reduced release of PP in response to sham feeding or insulin-induced hypoglycemia has been observed in some patients with FD, suggesting that the efferent vagal function is impaired in these patients.[86] As mentioned earlier, acupuncture at ST-36 stimulates vagal efferent activity. It is conceivable that acupuncture at ST-36 would stimulate vagal efferent activity and improve the impaired gastric motility and delayed gastric emptying in FD patients.

An impaired accommodation reflex has been documented in 30% of patients with FD.[24] The accommodation reflex is mediated via the vago-vagal reflex, which involves a vagal efferent pathway that uses nitric oxide (NO) as the final neurotransmitter mediating gastric relaxation.[88] It is also conceivable that acupuncture at ST-36 would increase vagal activity, resulting in potentiation of the accommodation reflex in FD patients.

Nausea and vomiting, common symptoms in patients with FD, may be treatable by acupuncture. The antiemesis mechanism of acupuncture at PC-6 is still unknown. Emetic stimuli from the GI tract mainly involve the vagus nerve, which has two types of afferent fibers involved in the emetic response: mechanoreceptors located in the muscular layer as well as chemoreceptors located in the mucosal layers.[89] Stimulation of the vagal afferents leads to activation of the CTZ in the area postrema. The emetic center located in the lateral reticular formation of the medulla oblongata coordinates efferent impulses through the vagus, phrenic, and spinal nerves of the abdominal musculature during the action of vomiting.[90,91] The antiemetic effect of acupuncture at PC-6 is mediated via the central opioid pathway;[64] thus, the antiemetic effect of acupuncture seems to be due to its inhibitory action on the vomiting center.

Somatosensory stimulation on the hand raises the discomfort threshold to gastric distension.[12] Patients with FD have altered gastric perception.[85] Somatosensory stimulation by TENS on the hand raises the discomfort threshold to gastric distension in FD patients.[12] It remains to be investigated whether acupuncture attenuates gastric hypersensitivity in FD patients.

IBS

IBS is one of the most common GI disorders in Western society, affecting around 15% of the population, especially young adults. The cause(s) of IBS and effective treatment(s) have remained elusive. There is not enough clinical evidence and few prospective well-randomized clinical studies to support the effectiveness of acupuncture on IBS.[33]

Symptoms of IBS correlate with specific autonomic nervous system abnormalities.[92] Because acupuncture is known to influence autonomic function,[43,44,46,47] acupuncture may be useful in selected cases of IBS.

Several reports have supported a positive effect of acupuncture on constipation. In a report on acupuncture treatment success after one and a half years of follow-up in 520 patients treated with acupuncture for different diseases, acupuncture treatment of constipation was successful 80% of the time.[93] Compared with a placebo, Chinese herbs and ear-acupuncture accelerated restoration of bowel peristalsis and minimized abdominal distension and urinary retention, while epidural morphine prolonged them.[94]

Xiong and Deng[95] treated 21 patients with constipation-associated diabetes mellitus with daily acupuncture at BL-32 (back) and ST-36 for 5 days. Only four patients needed a second treatment at the 6 month follow-up.[95] Recently, the successful treatment by acupuncture at LI-4 of constipation in children has been reported. The basal opioid activity was lower in the constipated children than in the control population and increased gradually up to the control level after ten true acupuncture sessions.[96]

Acupuncture at ST-36 stimulates the parasympathetic pathway and accelerates colonic transit in rats.[50] The stimulatory effects of acupuncture at ST-36 on colonic motility may be beneficial for constipation-predominant IBS patients.

Accelerated transit through the proximal colon is a factor in the pathophysiology of diarrhea-predominant IBS.[27,97] As the motility of the proximal colon is regulated via the vagal nerve, it is conceivable that a procedure inhibiting vagal activity would be useful in treating diarrhea-predominant IBS. Acupuncture has been used in veterinary medicine to control diarrhea in pigs.[98] In humans, case reports have shown noted beneficial effects of acupuncture for infantile diarrhea.[99]

Acupuncture at CV-12 has been used to treat patients with abdominal pain.[33,36] It is possible that acupuncture at CV-12 inhibits colonic transit by stimulating the sympathetic efferent pathway.[44]

Most patients with functional disorders of the GI tract appear to have inappropriate perception of physiological events and altered reflex responses in different gut regions.[100] Fedotozine, a kappa opioid receptor agonist, is capable of reversing the visceral hypersensitivity observed in IBS patients.[101,102] Fedotozine acts on the peripheral opioid receptors, rather than on central opioid receptors.[101] In contrast, acupuncture-induced analgesia appears to be mediated via the central opioid receptors.[74,75]

It has recently been shown that combined electrical acustimulation at ST-36 and PC-6 significantly increases the threshold of rectal sensations induced by rectal distension in IBS patients.[103] The results of this pilot study suggest that combined acustimulation at ST-36 and PC-

6 can reduce visceral perception in IBS patients.[103] Several studies indicate that fMRI has the potential to elucidate effects of acupuncture on brain activity in humans.[104–107] However, it remains unknown whether acupuncture attenuates the CNS activation induced by rectal distension.

Conclusion

In some patients with GERD[79] or FD,[24] esophageal peristalsis and gastric motility are impaired. The stimulatory effects of acupuncture at ST-36 on GI motility may be beneficial in patients with GERD or FD, as well as in constipation-predominant IBS patients who show delayed colonic transit.[28,29]

In contrast, the inhibitory effects of acupuncture at CV-12 on GI motility may be beneficial in diarrhea-predominant IBS patients, because enhanced colonic motility and accelerated colonic transit have been reported in such patients.[27,97]

It is conceivable that acupuncture at CV-12 may also inhibit gastric acid secretion via the somatosympathetic pathway. Therefore, acupuncture at CV-12 may be beneficial in GERD patients. The antiemetic effects of acupuncture at PC-6 may be beneficial in patients with FD, and the antinociceptive effects of acupuncture at PC-6 and ST-36 may be beneficial in patients with visceral hypersensitivity.

In the future, it is anticipated that acupuncture will be used to treat these patients in addition to the current therapy. This would also significantly reduce the cost of medical treatment.

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