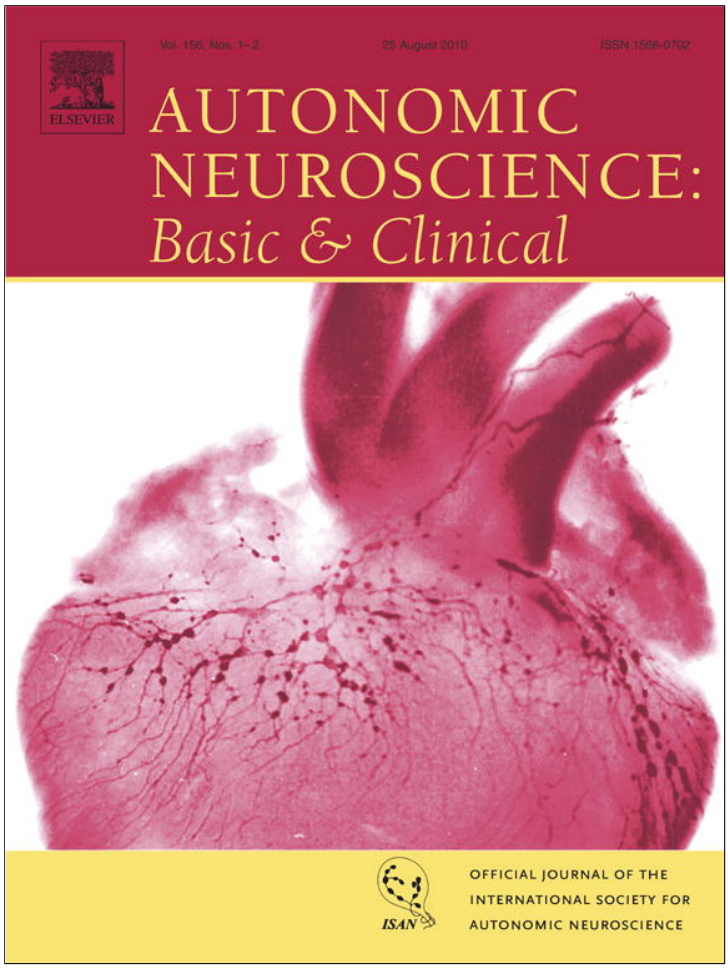

Autonomic Neuroscience: Basic and Clinical 156 (2010) 15–18

Contents lists available at ScienceDirect

Autonomic Neuroscience: Basic and Clinical

journal homepage: www.elsevier.com/locate/autneu

Review

Acupuncture regulates gut motility and secretion via nerve reflexes

Eitaro Noguchi

Faculty of Health Sciences, Graduate School of Technology and Science, National University Corporation Tsukuba University of Technology, Japan

ARTICLE INFO

Article history:
Received 21 October 2009
Received in revised form 16 June 2010
Accepted 22 June 2010

Keywords:
Gastric motility
Duodenal motility
Gastric acid secretion
Spinal reflex
Supra-spinal reflex
Rat

ABSTRACT

Digestive disorders impose a heavy medical and economical burden on society and they represent one of the most common reasons for seeking medical consultation. Acupuncture is one of the procedures available to treat these conditions; however, partly because of the limited scientific evidence as yet obtained, the method has not been widely accepted by the medical community as an evidence-based effective treatment.

This article presents some recent experimental work on the effectiveness of acupuncture in changing motility in the stomach and duodenum in anesthetized rats. We have shown that electrical or mechanical acupuncture of abdominal points inhibits visceral motility; the effect is due to a spinal reflex that involves activation of sympathetic nerve fibers and requires a peripheral stimulation of skin or muscles capable of activating group VI afferent nerve fibers. In contrast, acupuncture to a hindlimb enhances gastric or duodenal motility, and the reflex at work is supra-spinal and involves the vagus nerve; the peripheral stimulation activates type III afferent fibers.

In addition to the reflexes that are activated, the effects of acupuncture may be mediated via centers in the limbic system, the hypothalamus and the brain stem.

Contents

1. Introduction

Digestive disorders account for a major medical and economical burden on society and they represent one the most common reasons for seeking medical consultation.

Substantial amount of clinical work has been focused on the effects of acupuncture on the digestive tract, to an extent greater that the work on other systems. A detailed review on the uses of acupuncture in gastrointestinal dysfunctions has been published recently (Takakahashi, 2006). In spite of this and in spite of the long-established engagement of Japanese scientists in the study of acupuncture, the mechanisms involved in the medical effects of acupuncture remain poorly understood.

As long ago as 1906, the Japanese Government invited Kinnosuke Miura, a Professor at the University of Tokyo, to investigate the effect of acupuncture treatment. Professor Miura's work was focused on the physical responses to acupuncture, and neither in his work nor in subsequent studies were the actual mechanisms involved in generating these responses investigated (Miura, 1906).

In basic studies on somato-visceral reflexes it was shown that these reflexes are strongly associated with the effects of acupuncture and that, in anesthetized animals, somato-sensory stimulation of skin or muscles, such occurring in acupuncture, changes the motor activity of the gastrointestinal tract (Babkin and Kite, 1950; Jansson, 1969).

E-mail address: enoguchi@k.tsukuba-tech.ac.jp.

1566-0702/$ – see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.autneu.2010.06.010

Recent studies have investigated in more detail the changes in motility of the gastro-pyloric region and of the duodenum that are induced by somato-autonomic reflexes. In 1975, Sato and colleagues observed that pinching of the abdominal skin of anesthetized rats induced a decrease of intraluminal pressure in the stomach. This decrease of intra-gastric pressure persisted in spinalized animals, but disappeared after bilateral severance of the splanchnic nerves; the authors, therefore, concluded that the effect of acupuncture is based on a spinal cord reflex and involves the gastric sympathetic nerves (Sato et al., 1975).

In a more detailed study, Kametani and colleagues applied acupuncture stimulation to different regions of the body. By pinching the skin in the abdominal and thoracic region of anesthetized rats they observed inhibition of gastric motility; in contrast, stimulation of skin or muscles of the limbs produced an excitatory response, namely an increase in motor activity. During the inhibitory response to stimulation of the trunk, there was an increased activity in the gastric sympathetic nerves, whereas the excitatory response to stimulation of a limb was accompanied by increased nerve activity in the vagus nerve. The authors confirmed that the effect of acupuncture stimulation of the trunk persisted in spinalized animals; in contrast, the excitatory response to limb stimulation was abolished in spinalized animals, a result clearly showing that the excitatory response to acupuncture stimulation of a limb involves the vagus nerve and is a supra-spinal reflex (Kametani et al., 1979).

Here we present recent basic studies mainly by our group on the mechanism of acupuncture by somato-autonomic reflexes and on the acupuncture mechanism of reflex regulation of the gastro-duodenal function in anesthetized rats.

2. Gastric motility

2.1. Manual acupuncture stimulation

In 1993, Sato and his colleagues observed the effect of manual acupuncture stimulation in anesthetized rats by recording continuously the intra-gastric pressure by means of a balloon inserted into the gastro-pyloric region. The authors inserted a needle (340 μm diameter) about 4–5 mm deep into the subcutaneous and the muscular layers at several locations over the entire body and delivered acupuncture by twisting the needle for 60 s; in each case, the effect that they observed was either and increase or a decrease of gastric motility (Figs. 1 and 2).

Acupuncture inhibited gastric motility when it was applied to an abdominal location, and this effect was due to an increased activity of the efferent fibers in the gastric sympathetic nerves. The increase of gastric motility in the case of acupuncture stimulations to a limb resulted from increased activity of the efferent fibers of the gastric vagal nerves. Both the inhibitory and the excitatory responses were induced by acupuncture to the skin or the muscle separately or to both combined.

Acupuncture to an abdominal location increased the activity of afferent fibers of the lower thoracic spinal nerves; when the lower thoracic spinal nerves were severed, an inhibition of gastric motility did not take place when an abdominal location was stimulated with acupuncture. Similarly, acupuncture to a hind paw increased the activity of the afferent fibers of the sciatic and the femoral nerves; when the femoral and sciatic nerves were severed, an increase in gastric motility did not follow acupuncture stimulation of a hind paw.

In the spinalized rats, gastric motility was still inhibited by acupuncture to an abdominal location; in contrast, however, acupuncture applied to a hind paw failed to elicit excitation of gastric motility. This result shows that the inhibition or the excitation of gastric motility to acupuncture applied to abdominal or to hind paw locations were spinal and supra-spinal reflex responses, respectively. Furthermore, the motility changes were not affected by the administration of naloxone, suggesting that effects occur through a different mechanism from acupuncture analgesia (Sato et al., 1993).

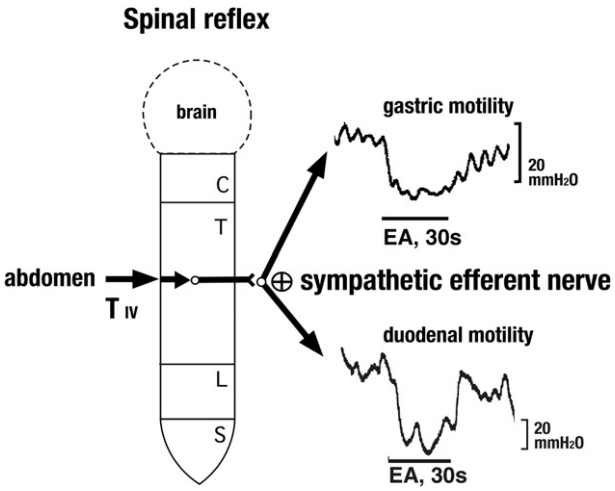

Fig. 1. Schematic drawing of the spinal somato-visceral reflex, illustrating the link between skin or muscle stimulation and changes in gastric and duodenal motility via activation of sympathetic nerve fibers. The arrow on the left indicates to point of acupuncture stimulation on the abdomen. A marked inhibition of gastric motility was recorded when the peripheral stimulation reached a threshold of intensity sufficient to activate group IV nerve fibers in the intercostal nerves. To the right, representative recordings of intraluminal pressure in the stomach and duodenum are displayed. The upper trace shows the inhibition of gastric motility during electrical acupuncture (EA). The lower trace shows the inhibition of duodenal motility during electro-acupuncture.

2.2. Electro-acupuncture stimulation

Yamaguchi and colleagues, also from our laboratory, confirmed that electro-acupuncture of various intensities to the abdomen or hindlimbs causes excitation or inhibition, respectively, of gastric motility. The authors further recorded the activity of afferent fibers from intercostal nerves and tibial nerve when an abdominal location or the hind paw, respectively, were stimulated, and examined the correlation between intensity of electric stimulation and magnitude of the gastric motility change.

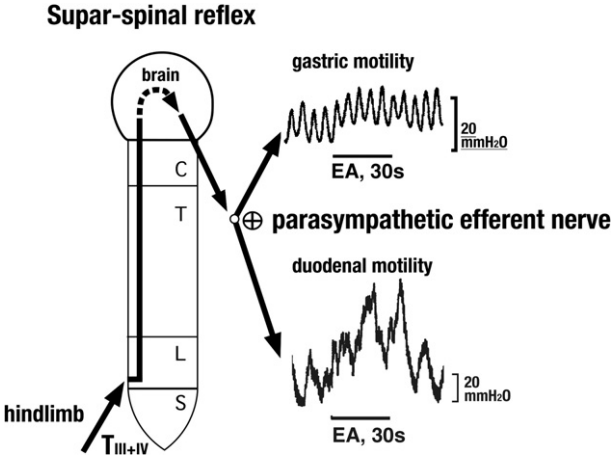

Fig. 2. Schematic drawing illustrating the supra-spinal somato-visceral reflex that produces enhanced gastric and duodenal motility via excitation of a parasympathetic nerve (the vagus nerve). The arrow on the left indicates the point of acupuncture on a hindlimb. A marked increase of gastric motility occurred during acupuncture on a hindlimb when the stimulation was sufficiently intense to activate high-threshold type III afferent fibers of type IV fibers in the tibial nerve. To the right, representative recordings of intraluminal pressure in the stomach and duodenum are displayed. The upper trace shows the inhibition of gastric motility during electrical acupuncture (EA). The lower trace shows the excitation of duodenal motility during electro-acupuncture (EA).

Table 1
Neural regulation of various gut functions induced by acupuncture and other somatic stimulation.

Function	Stimulation		Responses	Neural pathway	References
	Method	Region			
Gastric motility	MA	Abdomen	Decrease	Spinal reflex	Sato et al. (1993)
		Hind paw	Increase	Supra-spinal reflex	
	EA	Abdomen	Decrease	Spinal reflex	Yamaguchi et al. (1996)
		Hind paw	Increase	Supra-spinal reflex	
	Pinch	Abdomen	Decrease	Spinal reflex	Kametani et al. (1979), Sato et al. (1975)
		Hind paw	Increase	Supra-spinal reflex	
Duodenal motility	EA	Abdomen	Decrease	Spinal reflex	Noguchi et al. (2003)
		Hind paw	Increase	Supra-spinal reflex	
	Pinch	Abdomen	Decrease	Spinal reflex	Sato and Terui (1976)
		Hind paw	Increase	Supra-spinal reflex	
Gastric acid secretion	EA	Hind paw	Increase	Supra-spinal reflex	Noguchi and Hayashi (1996)
			Decrease	Endogenous opioids	Jin et al. (1996)

MA: manual acupuncture, EA: electro-acupuncture.

In this study, the authors also identified the nerves through which the electro-acupuncture stimulations works. They observed that the responses occurred above the threshold level of electro-acupuncture stimulation intensity at which group IV fibers are excited at the abdominal locations, but above the threshold level at which group III with high thresholds and group IV fibers are excited with stimulation at the hind paw.

Accordingly, they concluded that the stimulation at the body trunk location and that at the hindlimb were transmitted by different types of nerve fiber (Yamaguchi et al., 1996).

3. Duodenal motility

As regards duodenal motility, Sato and co-workers measured the changes caused by pinching stimulation and reported that noxious stimulation to abdominal locations produces duodenal motor inhibition via a spinal reflexes (Sato and Terui, 1976). More recently, we (Noguchi and colleagues, 2003, ref. Noguchi et al., 2003) measured duodenal motility by a method similar to the one originally used to measure gastric motility, and we examined the correlation between intensity of electro-acupuncture and changes in duodenal motility. We showed that in order to decrease duodenal motility, electro-acupuncture stimulation to an abdominal location needs to be strong enough to excite group IV fibers in the intercostal nerves. In contrast, in order to increase duodenal motility, electro-acupuncture stimulation to a hind paw needs to be strong enough to excite the higher-threshold group III fibers of the tibial nerve. In the same study we also showed that the changes in duodenal motor activity occur via a nerve path similar to that affecting gastric motility (Noguchi et al., 2003).

4. Gastric secretion

The first public presentation given at an international conference to link acupuncture treatment and gastric secretion was given by Sodipo and Falaiye at the University of Lagos in Nigeria in 1979 (Sodipo and Falaiye, 1979). The authors treated a group of patients with duodenal ulcer and a group of patients with dyspepsia but no ulcer, applying various regimens of acupuncture for six weeks. The tests showed that acupuncture was effective in reducing gastric acid secretion.

With an experimental approach in the laboratory, we have investigated acid secretion in anesthetized rats. By applying electro-acupuncture stimulation to the acupoint ST-36 we obtained an increase in gastric secretion; the effect was abolished when either the sciatic nerve or the vagus nerve was cut, but it persisted after cutting the splanchnic nerves. We put forward the conclusion that the stimulation of gastric secretion induced with acupuncture is based on a somato-autonomic reflex (Noguchi and Hayashi, 1996). However, other factors play a role, including hormonal factors and influences from the brain (Table 1).

Studies on the effect of acupuncture on gastric acid secretion have confirmed that somato-autonomic reflexes are involved (Noguchi and Hayashi, 1996) and it has also been shown that endogenous opioids play a role (Jin et al., 1996). However, the actual mechanisms at work remain unclear and further studies will be required.

5. Conclusion

Acupuncture stimulation, either mechanical or electrical, to specific location of skin and superficial skeletal muscles of the abdomen and the hindlimb is capable of modifying gastric motility. Application of acupuncture to abdominal locations of skin or muscle induced a decrease in gastric motility in anesthetized rats, via a spinal reflex that activates sympathetic efferent nerve fibers. Application of stimulation to a limb caused increase in gastric motility via a supra-spinal reflex that activated vagal nerve fibers. In addition, acupuncture of an abdominal location is effective in producing the inhibitory response only if sufficiently intense to activate group VI afferent nerve fibers in the intercostal nerves. Stimulation of a hindlimb is effective when it is strong enough to activate high-threshold group III nerve fibers in the tibial nerve. As for duodenal motility, acupunctures have similar effects and work through similar mechanisms as in the case of gastric motility.

In spite of recent studies, our understanding of the mechanisms involved in the effects of acupuncture on autonomic functions is still uncertain and open to investigation.

References

Babkin, B.P., Kite Jr., W.C., 1950. Central and reflex regulation of motility of pyloric antrum. J. Neurophysiol. 13, 321–334.
Jansson, G., 1969. Extrinsic nervous control of gastric motility. An experimental study in the cat. Acta Physiol. Scand. Suppl. 326, 1–42.
Jin, O.H., Zhou, L., Lee, K.Y., Chang, T.M., Chey, W.Y., 1996. Inhibition of acid secretion by electrical acupuncture is mediated via beta-endorphin and somatostatin. Am. J. Physiol . G 524–530.
Kametani, H., Sato, A., Sato, Y., Simpson, A., 1979. Neural mechanisms of reflex facilitation and inhibition of gastric motility to stimulation of various skin areas in rats. J. Physiol. 294, 407–418.
Miura, K., 1906. On acupuncture treatment. Chugai Iji Shinpo 627, 23–26 (in Japanese).
Noguchi, E., Hayashi, H., 1996. Increases on gastric acidity in response to electro-acupuncture stimulation of the hindlimb of anesthetized rats. Jpn J. Physiol. 46, 53–58.
Noguchi, E., Ohsawa, H., Tanaka, H., Ikeda, H., Aikawa, Y., 2003. Electroacupuncture stimulation effects on duodenal motility in anesthetized rats. Jpn J. Physiol. 53, 1–7.

Sato, A., Sato, Y., Shimada, F., Torigata, Y., 1975. Changes in gastric motility produced by nociceptive stimulation of the skin in rats. Brain Res. 87, 151–159.
Sato, A., Sato, Y., Suzuki, A., Uchida, S., 1993. Neural mechanisms of the reflex inhibition and excitation of gastric motility elicited by acupuncture-like stimulation in anesthetized rats. Neurosci. Res. 18, 53–62.
Sato, Y., Terui, N., 1976. Changes in duodenal motility produced by noxious mechanical stimulation of the skin in rat. Neurosci. Lett. 2, 189–193.
Sodipo, J., Falaiye, J.M., 1979. Acupuncture and gastric acid studies. Am. J. Chin. Med. 7, 356–361.
Takahashi, T., 2006. Acupuncture for functional gastrointestinal disorders. J. Gastroenterol. 41, 408–417.
Yamaguchi, S., Okada, K., Ohsawa, H., Miyamoto, T., Yosikawa, K., Nishijo, K., 1996. Electro-acupuncture stimulation effects on gastric motility in anesthetized rats. J. Soc. Neuroveget. Res. 33, 39–45 (in Japanese).