Clinical anatomy of the splanchnic nerves

Abstract
Splanchnic nerves are bilateral visceral autonomic nerves. The thoracic, lumbar and sacral splanchnic nerves are sympathetic in function while the pelvic splanchnic nerves are parasympathetic. These nerves have connections to the celiac, aortic, mesenteric, hypogastric and pelvic plexuses. They control the functions of the gut and pelvic organs. Splanchnicectomies are sometime performed to alleviate intractable abdominal and pelvic pains.

Keywords: splanchnic nerves, thoracic, lumbar, sacral, pelvic, nervi erigentes, splanchnicectomy

Introduction
The splanchnic nerves are bilateral autonomic nerves that supply abdominal and pelvic viscera. They are constituted of motor nerve fibers going to the internal organs (visceral efferent fibers) and sensory nerve fibers coming from these organs (visceral afferent fibers). On each side of the human body, they include the thoracic splanchnic nerves (greater, lesser and least or lowest), lumbar splanchnic nerve, sacral splanchnic nerve and pelvic splanchnic nerve (nervus erigentis). All splanchnic nerves carry preganglionic (presynaptic) sympathetic fibers except for the pelvic splanchnic nerves that carry preganglionic parasympathetic fibers. Splanchnicectomy is the procedure used mainly for the control of intractable visceral pain. Detailed knowledge of the anatomy and variations of the splanchnic nerves is mandatory for proper performance of splanchnicectomies (Figure 1).

Figure 1 The autonomic nervous system.
The GSN and LSN terminate into the celiac ganglion while the ISN into the renal ganglion (behind the renal vessels). The celiac ganglion is a semilunar structure of small ganglionic masses connected together by nerve fibers. It lies on the crus of the diaphragm, on each side of the celiac arterial trunk. The middle suprarenal artery traverses the celiac ganglion and the right ganglion lies behind the inferior vena cava. The thoracic splanchnic nerves and celiac ganglia play an essential role in pain management for upper abdominal disorders, particularly chronic pancreatitis and pancreatic cancer. Splanchnic nerve dissection, splanchnic nerve thermocoagulation, transhiatal bilateral splanchnicectomy and celiac plexus block are options for splanchnicectomy in management of upper abdominal pain. Thoracoscopic splanchnic denervation (TSD) for chronic pancreatitis pain resulted in fewer patients on opioids and overall increases in pain thresholds.\(^8,9\)

In an experimental study on adult male dogs, each of the canine thoracolumbar splanchnic nerves consisted of two groups of nerve fibers. One group, designated as the intermesenteric splanchnic nerve, arose from the thoracic and L1 sympathetic ganglia, and reached the caudal mesenteric plexus along the anterior wall of the aorta. The other group, designated as the lumbar splanchnic nerve, branched from L2-L5 sympathetic ganglia, and reached the mesenteric vessels. These delicate nerves of the aortic plexus are liable to accidental iatrogenic damage during retroperitoneal surgeries; thus threatening male fertility and sympathetic functions of the supplied organs.\(^7\) The aortic plexus is connected to the superior hypogastric plexus that lies on the bifurcation of the abdominal aorta. Branches of the lumbar and sacral sympathetic chains form the superior hypogastric plexus. At the sacral promontory, this plexus divides into right and left inferior hypogastric (pelvic) plexuses from which nerve fibers spread out bilaterally to the pelvic vessels and organs.\(^8\)

In Sprague Dawley rats, celiac ganglionectomy (CGX) through surgical removal of the celiac ganglionic plexus was performed with consequent significant reduction of the norepinephrine concentrations in the entire splanchnic area and the mesenteric vessels. There was an abolishment of vasoconstriction of the mesenteric vessels in response to sympathetic nerve stimulation. These effects of CGX were mostly reversible as significant regeneration of sympathetic nerves in some organs was detected at five weeks after surgery.\(^9\) In the same animal species, stimulation of the superior common splanchnic nerve (innervating the celiac ganglia) had led to decreased food intake, increased metabolic rate, increased lean-to-fat ratio and improved body composition.\(^10,11\)

In immune challenges, the brain influences the immune function through a powerful neural reflex that suppresses the release of inflammatory factors (Figure 2). The efferent motor limb of this neural reflex lies in the splanchnic nerves and not in the vagi.\(^12\)

**The lumbar splanchnic nerve**

The lumbar splanchnic nerve, one on each side of the body, arises from the upper two ganglia of the lumbar part of the sympathetic chain (L1-L2). Its preganglionic sympathetic fibers run medially and downwards to join the aortic plexus where they synapse in the ganglia there and then the postganglionic fibers are distributed to the vessels, smooth muscles and glands of the hindgut and pelvic viscera.

The aortic plexus overlies the front and sides of the abdominal aorta between the origins of the superior and inferior mesenteric arteries. There is general agreement regarding constitution of the aortic plexus of both pre- and post-ganglionic nerve fibers. It is essentially concerned with the sympathetic supply of the hindgut, pelvic and urogenital organs. In post-mortem human male specimens, four distinct sympathetic ganglia within the aortic plexus were identified: the right and left sympathetic ganglion, the inferior mesenteric ganglion and the prehypogastric ganglion. The spemtric ganglia received L1 presynaptic nerves whereas the inferior mesenteric and prehypogastric ganglia received left and right L2 presynaptic nerves. These delicate nerves of the aortic plexus are liable to accidental iatrogenic damage during retroperitoneal surgeries; thus threatening male fertility and sympathetic functions of the supplied organs.\(^7\) The aortic plexus is connected to the superior hypogastric plexus that lies on the bifurcation of the abdominal aorta. Branches of the lumbar and sacral sympathetic chains form the superior hypogastric plexus. At the sacral promontory, this plexus divides into right and left inferior hypogastric (pelvic) plexuses from which nerve fibers spread out bilaterally to the pelvic vessels and organs.\(^8\)
The sacral and pelvic splanchnic nerves

The sacral splanchnic nerve, on each side, connects the sacral part of the sympathetic trunk (S1 ganglion) to the inferior hypogastric (pelvic) plexus. Its preganglionic sympathetic fibers ascend from the inferior to the superior hypogastric plexuses then to the aortic and inferior mesenteric plexuses (where they relay), then they go to innervate the hindgut. From each pelvic plexus, sacral splanchnic fibers also supply the pelvic vessels and organs.

Laparoscopic studies of the sacral nerve roots in women revealed delicate fibers emerging from the sacral roots S2, S3 and probably S4 to form the pelvic splanchnic nerve (PSN) on each side.22 Another laparoscopic study in adult male cadavers reported that the PSN (or nervus reditus) arose from the ventral primary rami of the second, third, and often the fourth sacral nerves; providing preganglionic parasympathetic innervation to the hindgut. The sacral splanchnic nerves emerged from the sacral sympathetic trunks, joined the pelvic splanchnic nerve and then both joined the right and left inferior hypogastric (pelvic) plexuses.23

In patients undergoing conventional PSN-sparing radical hysterectomy for cancer cervix uteri, intraoperative electrical stimulation (IES) of the roots of the PSN is recommended. Bladder function has also to be assessed by urodynamic study (UDS) before stimulation (IES) of the roots of the PSN is recommended. Bladder hysterectomy for cancer cervix uteri, intraoperative electrical hypogastric (pelvic) plexuses.

References

Conflict of interest

The author declares no conflict of interest.

Figure 3 The lumbar, sacral and pelvic splanchnic nerves.

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