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ORIGINAL ARTICLE

Clinical anatomy study of autonomic nerve with respective to the anterior approach lumbar surgery

Sheng Lu · Yong-qing Xu · Shan Chang · Yuan-zhi Zhang · Ji-hong Shi · Zi-hai Ding · Zhong-hua Li · Shi-zhen Zhong

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Abstract
Introduction Male genital dysfunction was recognized as a complication following anterior approach lumbar surgery. Disruption of efferent sympathetic pathways such as the abdominal aortic plexus (AAP) and superior hypogastric plexus (SHP) which lied pre-abdominal aorta and iliac artery had been thought as the main reason. Though there were some clinical reports of retrograde ejaculation, the applied anatomic study of the autonomic nerve anterior to the lumbar was little. The purpose was to find out a lumbar surgery approach which was ejaculation preservation through the detailed study of the anatomy and histology observation of the autonomic nerve anterior to the lumbar vertebrae.
Methods The lumbar region of ten male cadavers was dissected and analyzed. We investigated the relationship between the peritoneum and abdominal aorta, iliac artery and sacral promontory fascia, as well as the trend and distribution of the autonomic nerve and SHP anterior to the L5-S1. We also observed the distribution of autonomic nerve at retroperitoneum through hematoxylin and eosin (HE)-stained tissues pre-aorta, para-aorta, and pre-vertebrae sacrales.
Results Superior hypogastric plexus, which deviated to left, located in a triangle formed by the common iliac arteries and its bilateral branches, its truck sited anterior to the lumbarsacral space in seven cases (70%), and anterior to sacrum in three cases (30%); at the aortic bifurcation, SHP strided over left iliac artery from left-hand side, then located in front of sacrum in four cases (40%), and sifted to the left at the lumbar sacral promontory in six cases (60%); from both anatomic and histological view, the autonomic nerve plexus lying in an fascia layer of retroperitoneum.
Conclusion At the anterior approach lumbar surgery of trans-peritoneum, we should choose the right-hand side incision; the SHP should be pushed aside carefully from right to left along intervertebral disc. The accurate surgical plane was at the deeper layer of autonomical nerve fascia; we also could lift the complete autonomical nerve layer which lies behind the aorta and lumbar sacral promontory, so that the autonomic nerve could be preserved.

Keywords Lumbar · The autonomic nerve · Anterior approach · Clinical anatomy

S. Lu (✉) · Y.-q. Xu · J.-h. Shi
Department of Orthopedics, Kunming General Hospital, Chengdu Military Region, PLA, Kunming, China
e-mail: drlusheng@yahoo.com.cn

S. Chang
Department of Orthopaedics, The First Hospital of Chengdu Medical College, Chengdu, China

Y.-z. Zhang
Department of Orthopaedics, The First Hospital Affiliated to the Inner Mongolia Medical College, Hohhot, Inner Mongolia Autonomous Region, Chengdu, China

Z.-h. Ding · Z.-h. Li · S.-z. Zhong
The Clinical Anatomy Institute, The NanFang Medical University, Guangzhou, China

Introduction

Male genital dysfunction was recognized as a complication following anterior approach lumbar surgery in the 1960s and 1970s [4], and an incidence of up to 20% has been reported using the transperitoneal approach [14]. In 1981, Johnson [7] thought that the complication of retrograde ejaculation arose from the injury of superior hypogastric

plexus (SHP). With new implants and technique such as cages and minimally invasive spine surgery, anterior approach lumbar surgery had making an comeback in 1990s, the retrograde ejaculation after anterior approach lumbar surgery had been the important issue in spine surgery again [6, 16]. Disruption of efferent sympathetic pathways such as the abdominal aortic plexus (AAP) and SHP which lied pre-abdominal aorta and iliac artery had been thought as the main reason. Though there were some clinical reports of retrograde ejaculation, the applied anatomic study of the autonomic nerve anterior the lumbar was little. This anatomic study would get the better understanding of autonomic nerve anterior to the lumbar, and provided the anatomic basement of ejaculation-preserving alternatives in the anterior approach lumbar surgery.

Materials and methods

Ten men formaldehyde-preserved male cadavers had been observed. All visceral organs were removed for exploration of the pre-aortic and para-aortic and lumbosacral retroperitoneal regions. No other pathologic condition affecting the anatomy of the retroperitoneal was found. The parietal peritoneum anterior to the aorta, iliac common artery and vertebra was dissected bilaterally. By operation microscope, the feature of the trend and distribution of AAP, IMP and SHP, and the relationship between the retroperitoneum and the autonomic nerve anterior to the abdominal aorta, iliac common artery, lumbosacral region were observed. The autonomic nerve was stained by yellow color. Then one sample whose tissues of pre-aortic, para-aortic and pre-vertebra was selected and sliced into a series of microsection, the routine histo-section was made, paraffin-embedment and HE staining. The main interest of these dissections was to gain a deeper insight into the anatomic relationship between retroperitoneum tissues and abdominal aorta, prevertebral fascia, thereby to reveal the anatomic relationship between nerve and the covering fasciae.

Results

Anatomic observation of AAP and SHP

Abdominal aortic plexus, ascending to be celiac plexus, celiac ganglia and aorta mesial plate, and descending to form SHP, was distributed at the antero-external area of the abdominal aorta; above the aorta, inferior mesenteric plexus (IMP) surrounded inferior mesenteric artery (IMA) and went along its branches. Lumbar sprinter nerve (LSN) was sent out from sympathetic nerve chain and moved toward pre-aorta plexus through para-aorta tissues (Fig. 1).

Fig. 1 Ventral view into abdomen. *A* abdominal aorta, *AAP* abdominal aortic plexus, *CIA* common iliac artery, *CIV* common iliac vein, *I* inferior mesenteric artery, *LSN* lumbar splanchnic nerve, *SC* sympathetic chain, *U* ureter, *V* inferior vena cava, *IMP* inferior mesenteric plexus, *SHP* superior hypogastric plexus, *PM* psoas muscle

A little of interweaved hoar fiber anterior to the aorta, which circumfused abdominal aorta, descends along the AAP at the area between the bilateral iliac arteries and forms the SHP. At the sacral promontory level, SHP divided into the left and right HGNs and got into small pelvis laterally. SHP trunk, about 8.9 ± 2.7 cm in length, 1.4 ± 0.7 and 1.7 ± 1.1 cm in width from above down, is located in a triangular area formed by the aorta and the common iliac arteries. The major part of SHP lies anterior to the L5-S1 space in seven cases (70%), and anterior to the S1 in three cases (30%). At the level of sacral promontory, the main part of SHP lays left side in four cases (40%, Fig. 4a), and shifted slightly to the left of median line in six cases (60% Fig. 4b). At right-extra side, very thin nerve fiber of SHP could be distinguished in the microscope.

Anatomic observation of retroperitoneal fascia

The tissue cavity of under the retroperitoneal and at the area above abdominal aorta is continuous, AAP and SHP

lie in this cavity. A thin layer of fat sometimes separated AAP and SHP from aorta and retroperitoneal. This typical plane covered aorta, iliac common artery, para-aortic fat cavity, inferior cava vein (IVC) and lumbarsacral promontory. The fibrous cable in front of sacrum, which was formed by SHP, together with nerve tissue of retroperitoneum, could not be moved with peritoneum. The autonomic nervous plexus, which lies in the loosen tissue deeper under the retroperitoneum layer (Figs. 2, 3), could be regarded as a integrate layer, which we called as nerve fiber layer, and can be disconnected from sacral promontory carefully. The injury of autonomic nerve could be avoided if we stripped this nerve fiber layer anterior to the vertebra (Fig. 4).

Histological observation of the retroperitoneal tissues anterior to the vertebra

From HE-stained tissue slice, we discovered a complex tissue layer at retroperitoneum, which included lymph, blood vessel, nerve and fat, they covered abdominal aorta and its retroperitoneal ramification, inferior cava vein, nephric ducts and musculus psoas major. Looking into the pre- and para-aortic tissues at retroperitoneum microscopically, we also discovered small blood vessels and autonomic nerve—for the latter, there were also some lamina fat and collagen fibrils under it. These anatomical feature show the autonomic nerve could be regarded as an independent tissue layer (Fig. 5).

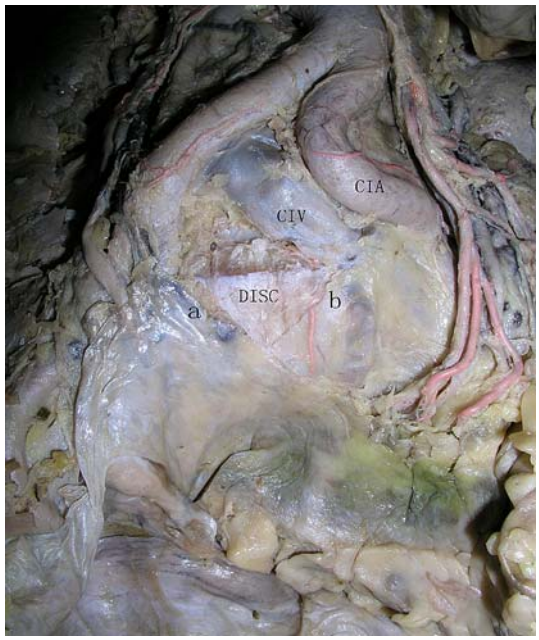

Fig. 3 The different plain in the front of disc including of the retroperitoneal and autonomic nerve fiber: **a** retroperitoneal and **b** automatic nerve fiber plain

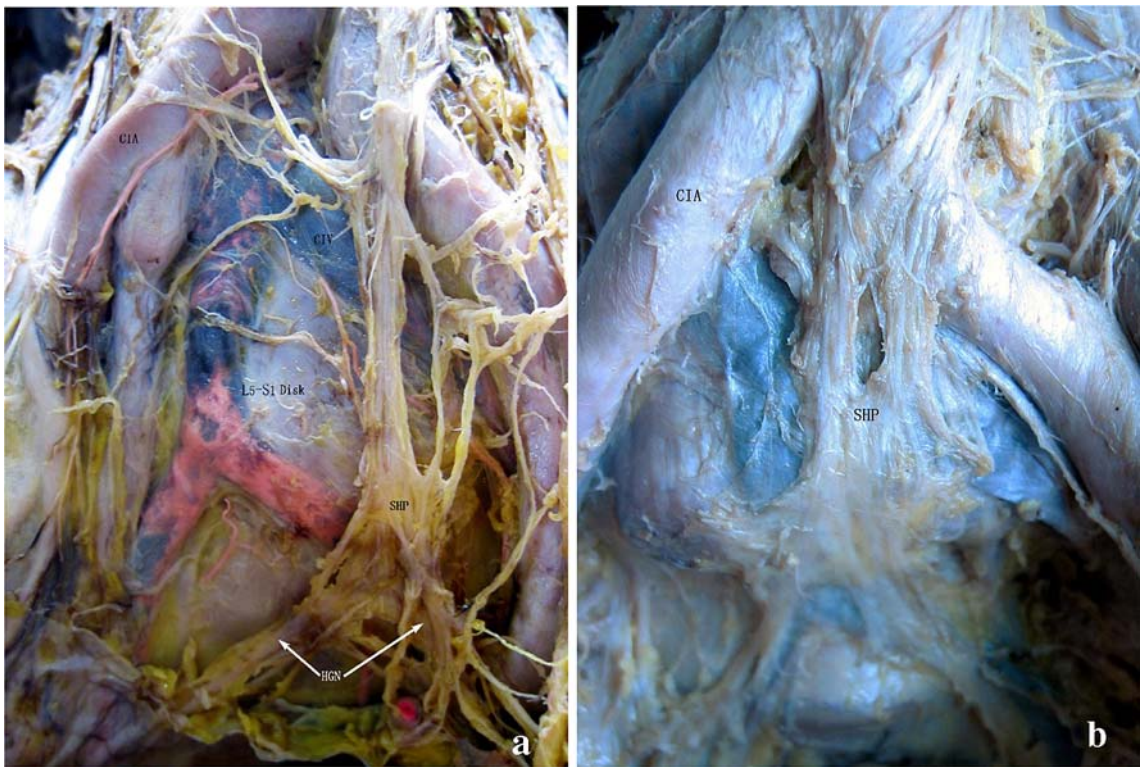

Fig. 2 The position of the major part of SHP on the lumbarsacral: **a** SHP rests on the left level of the sacral promontory and **b** SHP rests on the slightly shifted to the left level of the L5-S1 intervertebral disc

Fig. 4 Dissection of the SHP

Discussion

The nerve center of ejaculation reflex located in the T12-L4, the nerve impulse, which passes through the LSN, AAP, SHP and hypogastric nerve (HPN), leads to spermatize by causing the intensive muscle contraction in urethra and perineum. These nervous fibers seldom distributed over the sphincter muscle of urinary bladder, but widely over the base and cervix of bladder, and proximal urethra, their dominated area was termed genito-constrictor, which acted as a protector of ejaculation. The interrupt of sympathetic efferent pathway, which supplied bladder cervix, spermatic ducts and prostate, could lead to improper relaxation of sphincter muscle of urinary bladder and retrograde ejaculation [15], then resulted in sterility.

The relation between anterior approach lumbar surgery and retrograde ejaculation

Ejaculation disorder was a common complication of anterior approach lumbar surgery, with the incidence varying from 0.42 [2] to 27.3% [9]. Due to some reasons, such as some statistics of paper did not distinguish male patients from female one and the patients would not talk their retrograde ejaculation symptom if they were not specifically asked about it, so the actual incidence of retrograde ejaculation in anterior approach lumbar surgery was higher than that had been reported. The statistical incidence of retrograde ejaculation from different reports ubi infra (Table 1).

The anatomic and histological observation on pre-vertebra fascia and its correlation to surgery

From anatomical study, we found AAP and SHP situated in a loosen connective tissue layer at retroperitoneum with continuity, thus this layer could be regarded as a nerve fiber layer, which coincided with Van findings [17]; then we found this nerve fiber layer separate abdominal aorta, sacral promontory from retroperitoneum and fell into two potential spaces, the fat tissue; anterior space was thick and the posterior was comparatively thin, both spaces contained few blood vessels. In view of these features, this nerve fiber

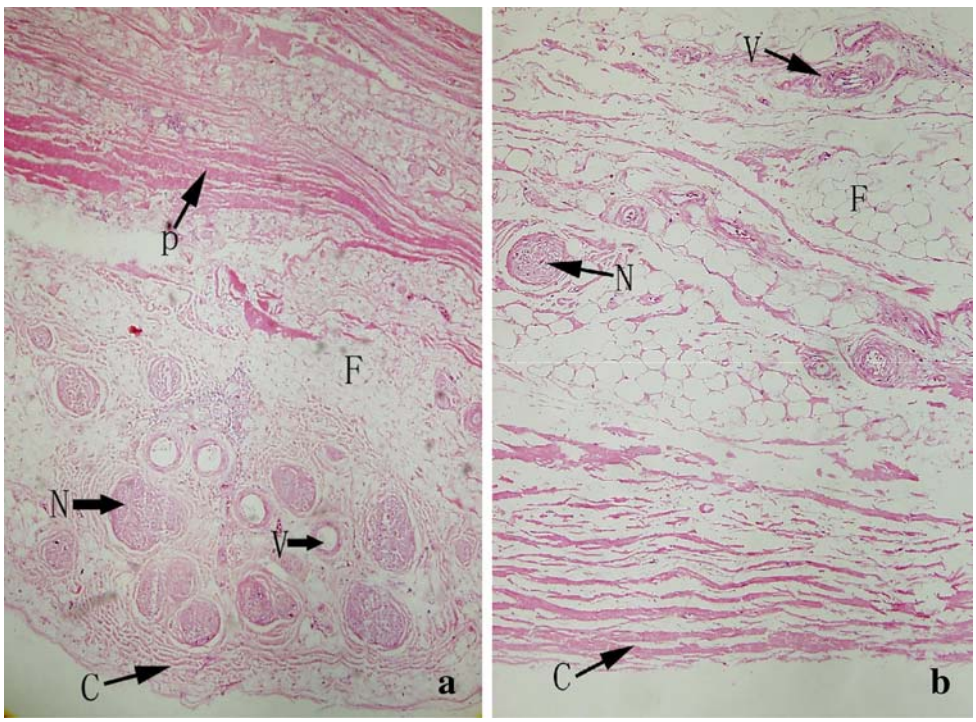

Fig. 5 Microscopic section of predisc and pre-aortic tissue: **a** fiber plain of predisc, **b** fiber plain of pre-aortic. *C* connective tissue septum, *F* fat tissue, *N* automatic nerve, *V* vascular, *P* peritoneum

Table 1 The retrograde ejaculation investigation of different reports

Reporter	Incidence of retrograde ejaculation
Enrique et al. [2]	12% (3/24)
Regan et al. [10]	5.1% (11/215)
Faciszewski et al. [3]	0.5 (2/371)
Goldner et al. [5]	3% (3/100)
Stauffer and Coventry [14]	2.7% (83)
Inoue et al. [6]	5.9% (12/200)
Tiusanen et al. [16]	17.5% (9/40)
Kleeman et al. [8]	16% (11/69)
Zdeblick [18]	6% (4/68)
Katkhouda et al. [9]	27.3% (3/11)
Sasso et al. [12]	13.3% (4/30)

layer could act as a surgical plane and be stripped from aorta and sacral promontory. The ramification of median sacral artery, lies between abdominal aorta, sacral promontory and the nerve fiber layer, was likely lacerated when disconnecting, if electrocoagulation had to be employed, the bipolar was better than the MONOpolar coagulation [10]. Robert [11] recommended, when disconnecting prevertebra tissues, it was better to make the blunt disconnection at the surface of intervertebral disc so that the injury of autonomic nerve could be avoided. So did we observe in our study. But he did not notice another important problem—the tissue layer of retroperitoneum. Though available literature had not mentioned this problem, it was very significant that operated at accurate surgical plane could avoid injury of AAP and SHP.

The surgical problem of anterior approach lumbar surgery respecting autonomic nerve reservation

Up to now, there was not a consensus at the prevention from retrograde ejaculatory in anterior approach lumbar surgery. Quite a number of them thought when handling any vertical tissue in front of the lumbar-sacra vertebra, the operator should handle with care and should not use the electrocoagulation. Based on our anatomical and clinical study, we brought forward the opinion of avoiding autonomic nerve injury in anterior approach lumbar surgery. Our study provided anatomical foundation for prevention of ejaculatory function in minimally invasive anterior approach lumbar surgery.

The selection of incised location of retroperitoneum

According to the feature of SHP, first of all, we suggested the right-side incision of retroperitoneum on the ground of the following: (1) the major part of SHP lies frequently to left of the sacrolumbar; (2) the inferior mesenteric pleux lies on the left side, and the incision here was likely lead to injury of mesocolon pelvinum; (3) at the right side, the right iliac artery always lies anterior to the iliac vein with thicker and more stressful wall than the veins. Secondly, we suggested the incised location should be selected at medial side of right internal iliac artery when operator handled peritoneum in front of the lumbar sacral promontory. One clinical research led by Kleeman proved that there were much more retrograde ejaculatory complication caused by left-side incision (75%), but no one complication happened by right-side incision. He also recommends the left-side incision to avoid autonomic nerve injury, which coincided with our study, and so did some other researches [13].

Accurate surgical plane

The above-mentioned experiment clearly displays a nerve fascia layer at retroperitoneum, and the histological inspection further approved autonomic nerve lying above a collagenous fiber. Such characteristic made it possible to remove that tissue space and all internal contents easily. Therefore the same surgical plane was demanded both at trans-peritoneum and retroperitoneum surgery.

Surgery strategy of SHP protection

The most important thing was to protect SHP when approached the area anterior to the L5-S1 intervertebral disc both at trans-peritoneum and retroperitoneum surgery. Our view was that the peritoneum was incised at the left side, instead of SHP, it was the nerve fiber layer which was disconnected in front of vertebra and lifted to the left. Moreover, the possibility of automatic nervous injury had been obviously increased if approached to the L4-L5 intervertebral disc and the segments above. At the anatomical point of view, it was unavoidable to disconnect one side LSN, regardless the left one or the right one. We thought, if needed, the disconnection of one side LSN was the right choice, because from experience of urological surgery, the clearing of hemi-lymph node could not produce significant influence on autonomic nerve, but the clearing of the bilateral would result in great influence. So we suggested that the peritoneum be pushed aside, then autonomic nerve layer be pushed aside also from deep layer, in this way, it was likely to damage the unilateral LSN, rather than AAP, IMP or SHP.

The influence on autonomic nerve at different surgical approaches

When discussed the retrograde ejaculatory problem in anterior approach lumbar surgery, Sasso et al. [12] thought the incidence caused by trans-peritoneum is ten times higher

than that which caused by trans-retroperitoneum, in diagram, author displayed his trans-peritoneum approach of medisecting the peritoneum to reach sacral promontory, and trans-peritoneum approach of disconnecting SHP at the left side. In 2004, Birch [1] commented on this surgery on the basis of 46 male patients who had undergone trans-peritoneum approach surgery without the complication of retrograde ejaculation. Instead of medisecting the peritoneum, they incised peritoneum at the right side, and disconnected autonomic nerve layer integrately.

Conclusion

Our research displayed clearly the characteristic of autonomic nerve distribution in front of lumbar vertebrae, and analyzed the possibility of interrupting autonomic nerve at different segments in anterior approach lumbar surgery, as well as the feasibility of the surgery approaches of autonomic nerve preservation. The anatomical knowledge concerning the technique of autonomic nerve preservation would contribute to clinical practice, at the same time, it provided the anatomic basement of ejaculation preservation in the anterior approach lumbar surgery.

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