

## ORIGINAL PAPER

# The spermatic ganglion in humans: an anatomical update

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### Abstract

The male gonad receives nerve fibers from the autonomic ganglionic system. By the present study, we aimed to bring detailed evidences, topographic and structural, on the spermatic ganglia (SG) in humans, as suppliers of autonomic fibers for the testis. We performed retroperitoneal dissections in 25 formalin-fixed human male adult cadavers. Histology used the Hematoxylin–Eosin and we also used Bielschowsky silver stains. Immunohistochemistry used antibodies for tyrosine hydroxylase. In 20/10 specimens, we identified left spermatic ganglia (LSG) at the aortic origin of the left testicular artery (LTA); in five specimens the LTA left the renal artery but LSG were juxtaposed on the aorta at about the level of origin of a normal LTA. In 15/25 cadavers, there were right spermatic ganglia (RSG) related to the right testicular artery (RTA) that in 12 cadavers had a pre caval disposition. A specimen with retrocaval RTA presented an inferior renal ganglion, supplying both the renal and the RTA. The SG presented renal, lumbar and intermesenteric roots. The inferior branch of the SG connected it to the inferior mesenteric plexus while its infero-lateral branch adjoined the testicular artery. Microscopy confirmed the SG as nervous ganglia and the respective neuronal populations were tyrosine hydroxylase positive, allowing us to consider these ganglia as sympathetic. We bring here the first-time evidence of the SG topography and cathecolaminergic nature in humans; this ganglion may influence the male gonad via the inferior mesenteric plexus and via the vascular path of the testicular artery.

**Keywords:** testis, tyrosine hydroxylase, testicular artery.

### □ Introduction

The male gonad receives nerve fibers from the autonomic ganglionic system. These fibers converge on the testis along two pathways, the superior and the inferior spermatic nerves. The superior spermatic nerve runs from the superior mesenteric ganglion alongside the testicular artery, whereas the inferior spermatic nerve originates in inferior mesenteric ganglion, accompanies the vas deferens and penetrates the testis [1].

Wrobel KH and Moustafa MN (2000) offered a suggestive description of the innervation pattern of the adult donkey testis where autonomous nerves reach the testis by three access-routes as funicular, mesorchial and caudal contributions; the funicular contribution accompanying the testicular artery and pampiniform plexus is the strongest and most important one [2]. These authors evaluated that the majority of the testicular nerves are dopamine beta-hydroxylase and tyrosine hydroxylase positive and thus they represent postganglionic sympathetic fibers.

In a previous paper reporting the existence in humans of the lumbar splanchnic ganglia we already described the spermatic ganglion (SG) as being consistently present and supplied by the inter-mesenteric plexus, the renal plexus and the aortico-renal ganglion [3]. We aimed here to bring supplementary evidences in order to complete and detail the anatomy and structure of these ganglia topographically related and sending off fibers with the testicular artery.

### □ Material and Methods

We performed retroperitoneal dissections in 25 formalin-fixed human male adult cadavers, at the level of the renal and testicular vascular pedicles, in order to identify the nervous ganglia topographically related to the testicular arteries origins, with their afferents and efferents. Once the respective nervous ganglia were identified, they were dissected out and submitted for histology and immunohistochemistry.

The histological analysis used the Hematoxylin–Eosin stain on paraffin-embedded specimens, with 8–10 µm slices.

As an alternate method for the histological diagnosis of nervous ganglia we used the Bielschowsky silver stains: the specimens were fixed, washed in distilled water and stained with 20% AgNO<sub>3</sub> for six days. After a rapid wash, the blocks were further treated with 1% pyrogallol for 24 hours then were washed, dehydrated and paraffin embedded. Sections were cut at 10 µm thick.

Immunohistochemistry was performed using the ABC method [4] by use of ready-to-use primary antibodies for tyrosine hydroxylase (TH), type IgG1, clone 1B5, mouse monoclonal, supplier Novocastra, catalog number NCL–TH [5].

Tyrosine hydroxylase is the first enzyme in catecholamine biosynthesis [6]. Controls for immunohistochemistry all reacted negatively.

The microscopic slides were observed and snapshots were taken using the working station ZEISS: microscope AxioImager M1 with an AxioCam HRC camera and the digital image processing software AxioVision. As the microscope was calibrated with the software, the pictures taken were scaled.

## Results

### On the presence of nervous ganglia topographically related to the testicular arteries

On the left side we identified the presence of a nervous ganglion that was inferior to the aortic origin of the left testicular artery (LTA) (Figures 1 and 2) in 20/25 specimens.

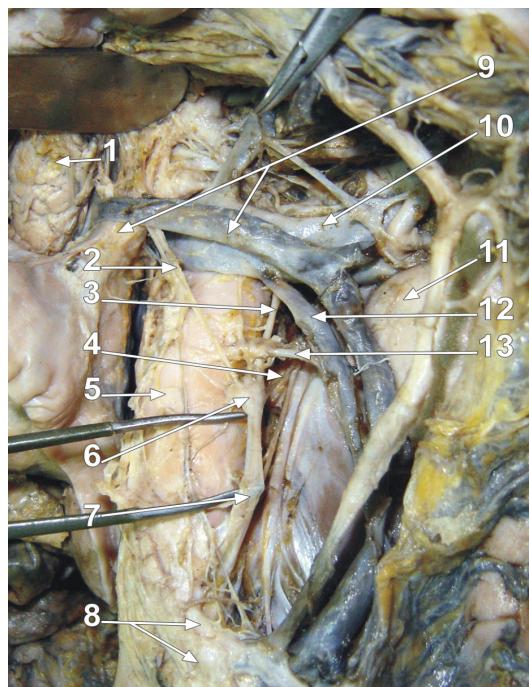
In 5/10 specimens with a LTA originating from the left renal artery and not from the abdominal aorta, a nervous ganglion was identified in a comparable topographic location as in the specimens with aortic origin of the LTA (Figure 3), thus its location seeming uninfluenced by a normal origin of the testicular artery.

All these identified ganglia were considered left spermatic ganglia and possessed the following general topographic relations:

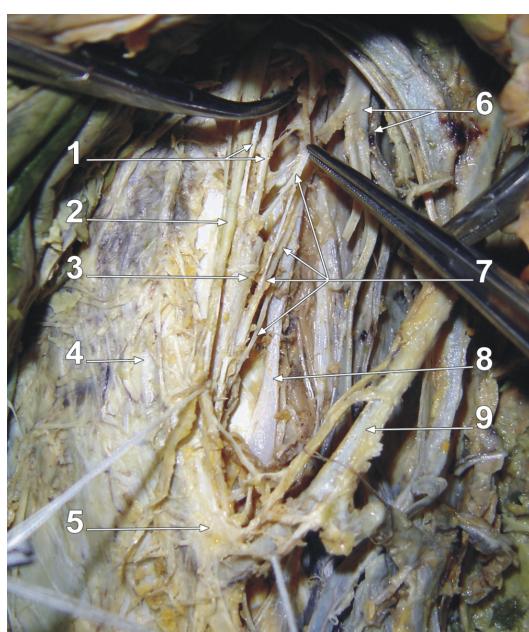
- posterior: with the para-aortic lymph nodes, the lumbar sympathetic trunk and the first two lumbar splanchnic nerves;
- postero-medial: the ganglia were applied on the abdominal aorta;
- superior: with the LTA origin;
- antero-lateral: with the vascular arch of Treitz, consisting of the left colic artery and the inferior mesenteric vein.



**Figure 1 – Dissection of a left spermatic ganglion (SG) – the topographic relations:** 1. Renal vein; 2. Renal root of the SG; 3. Abdominal aorta; 4. Left spermatic ganglion; 5. First lumbar splanchnic nerve; 6. Duplicate left testicular vein; 7. Inferior mesenteric vein; 8. Left testicular artery; 9. Left colic artery; 10. Lumbar sympathetic trunk; 11. Ureter.

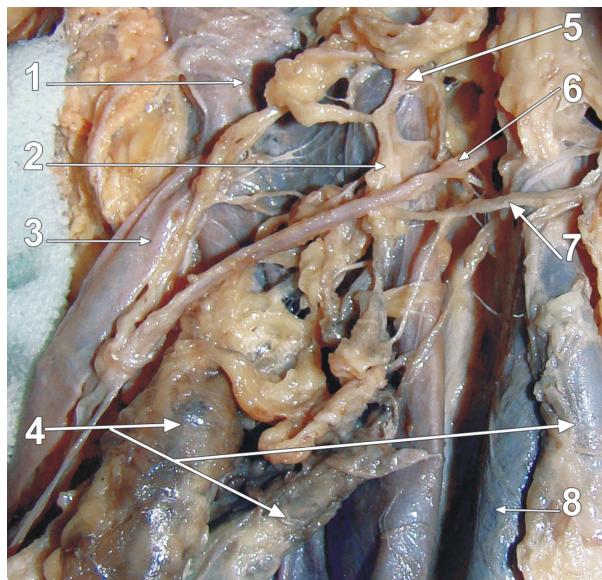


**Figure 2 – Dissection of a left spermatic ganglion (SG) – the roots and the branches:** 1. Pancreas (displaced); 2. Intermesenteric root of the SG; 3. Renal root of the SG; 4. Lumbar root of the SG, from the first lumbar splanchnic nerve; 5. Abdominal aorta; 6. Spermatic ganglion; 7. The large inferior branch of the SG; 8. Inferior mesenteric artery, plexus and ganglion; 9. Inferior mesenteric vein, muscle of Treitz; 10. Renal vein; 11. Left kidney; 12. Left testicular vein; 13. Left testicular artery.

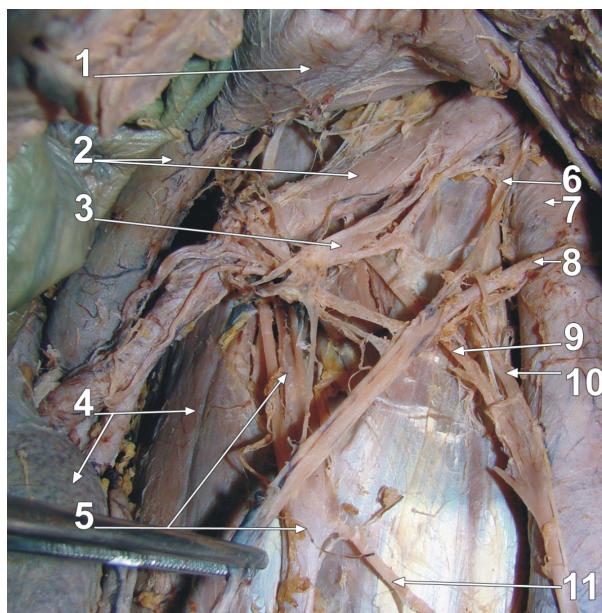


**Figure 3 – Dissection of a left spermatic ganglion (SG) in a specimen lacking an aortic origin of the left testicular artery the SG keeps its topographic location:** 1. Renal roots of the SG; 2. Intermesenteric nerve; 3. Spermatic ganglion; 4. Abdominal aorta; 5. Inferior mesenteric artery and plexus; 6. Left testicular vessels; 7. The branches of the first two lumbar splanchnic nerves connect to the SG and its inferior branch; 8. Lumbar sympathetic trunk; 9. Left colic artery.

On the right side we identified in 15/25 cadavers nervous ganglia topographically related to a right testicular artery (RTA) originating from the abdominal aorta (Figures 4 and 5).



**Figure 4 – Dissection of a right spermatic ganglion (SG) in a specimen with a pre caval course of the testicular artery:** 1. Inferior cava vein; 2. Right spermatic ganglion; 3. Right testicular vein; 4. Lymph nodes; 5. Renal root of the SG; 6. Right testicular artery; 7. Inferior branch of the SG; 8. Abdominal aorta.



**Figure 5 – Dissection of a right inferior aorticorenal ganglion:** 1. Inferior cava vein, cut and reflected; 2. Right renal vessels; 3. Inferior aorticorenal ganglion; 4. Right kidney, major psoas muscle; 5. Lumbar sympathetic trunk; 6. Superior spermatic nerve; 7. Abdominal aorta; 8. Right testicular artery; 9. First right lumbar splanchnic nerve; 10. Efferent branch of the renal plexus and spermatic nerve for the inferior mesenteric plexus; 11. Second right lumbar splanchnic nerve.

In 12/15 positive specimens the RTA coursed anteriorly to the inferior cava vein (ICV) and the related

ganglia also adopted a pre-caval disposition, were immediately located superior to the RTA (Figure 4) and we termed them right spermatic ganglia. In a single specimen, the RTA, originating the aorta, coursed posterior to the ICV, and its peri-arterial plexus was supplied by an inferior renal ganglion, that belonged to the renal plexus, at the inferior border of the right renal artery (Figure 5).

#### On the macroscopic connections of the spermatic ganglia

We considered the proximal connections of the spermatic ganglia as “roots” while the distal connections were defined as “branches”.

For each spermatic ganglion (SG) multiple roots were evidenced:

(1) A distinctive renal root, mainly emerged from the renal plexus and also supplied by the aortico-renal ganglion, was identified in all specimens that were positive for spermatic ganglia; that root was descending posterior to the renal vein and then close to the lateral border of the abdominal aorta; on the left side it also crossed posterior to the origin of the LTA (Figures 1 and 2) while on the right side, where the SG was above the RTA, that renal root was not directly related to the RTA (Figure 4);

(2) Lumbar roots, individually variable, were supplied by the first and the second lumbar splanchnic nerves (Figures 2 and 3) and entered the posterior aspect of the SG;

(3) An inter-mesenteric root, supplied by the intermesenteric plexus, up to the superior mesenteric ganglia and plexus (Figures 2 and 5).

Macroscopically the SG appeared rather as a main supplier of the inferior mesenteric ganglion, intercalated on the intermesenteric path connecting the mesenteric ganglia (superior and inferior), and secondary as a supplier of the superior spermatic nerve; we grouped the efferences of the SG in two classes:

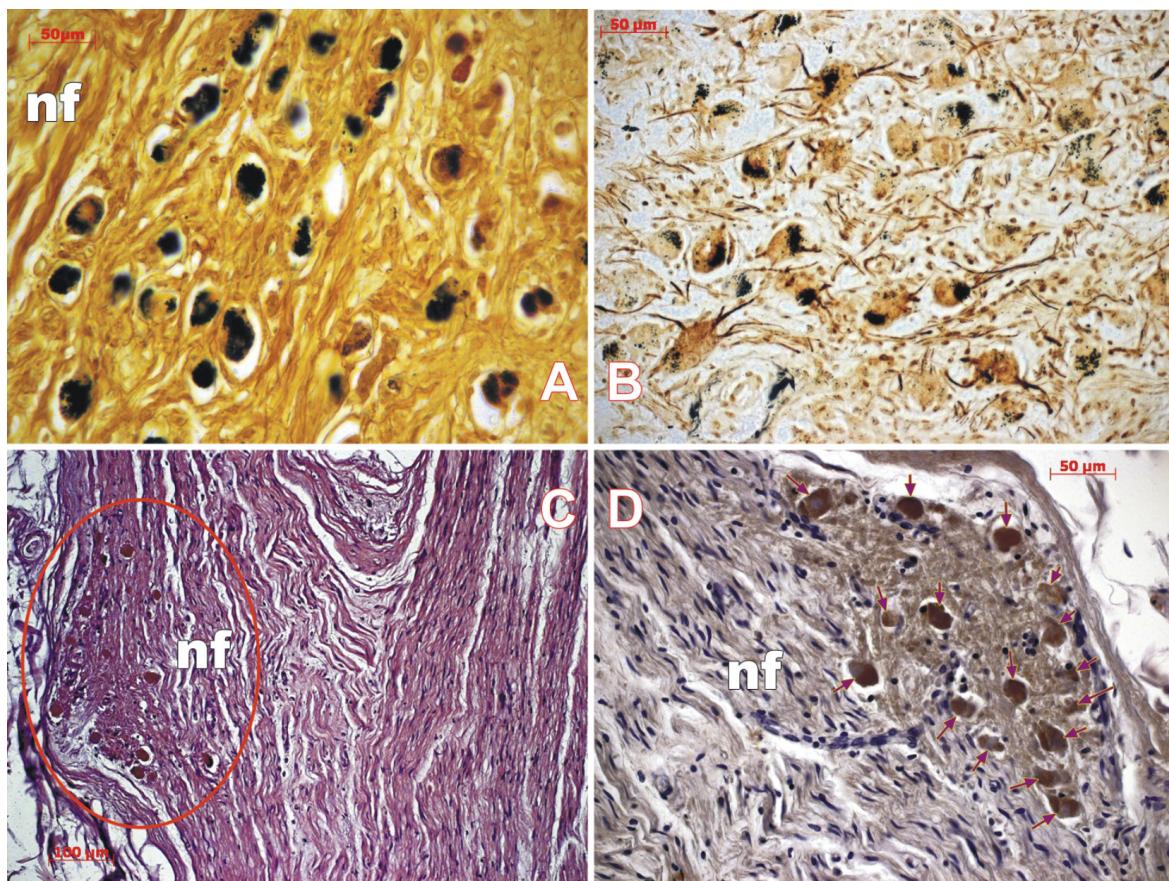
(a) The inferior branch, larger, distributed to the inferior mesenteric plexus and ganglia;

(b) The infero-lateral branch, that corresponds to the superior spermatic nerve and courses along the testicular artery.

#### On the microscopic diagnostic of the SG

The spermatic ganglia we identified by dissection were confirmed microscopically as nervous ganglia, consisting of neuronal multi-polar bodies and glial support (satellite cells). The amount of neurons was directly related to the macroscopic size of the ganglia. The small ganglia that macroscopically appeared as discrete nervous enlargements consisted of reduced neuronal populations, located extrinsic to the neural fibers and within the perineurium of the respective nerve. The same extrinsic location of the neurons was identified also in the large spermatic ganglia (Figure 6).

All the neurons in the spermatic ganglia we evaluated were immunopositive for tyrosine hydroxylase (TH) and thus were catecholaminergic, allowing us to consider these ganglia as sympathetic in nature.



**Figure 6 – Microscopic diagnostic of the spermatic ganglia:** (A and B) Bielschowsky silver stains of a left (A) and right (B) spermatic ganglion; (C) HE stain of a small right spermatic ganglion; (D) Neurons of the spermatic ganglia are TH-positive (arrows). The neuronal cell bodies of the spermatic ganglia are extrinsic to the neural fibers (nf) coursing at that level.

## Discussion

There are extremely few references that mention the spermatic ganglion (SG) as a distinctive anatomic structure. For example, *Gray's Anatomy* refers only to the spermatic plexus that is described as derived from the renal plexus, it receives branches from the aortic plexus and it accompanies the internal spermatic artery to the testis [7]. We also identified the respective connections but we brought several evidence-based improvements of the anatomical knowledge; the SG strongly appeared to us as a nodal relay on a longitudinal para-aortic autonomic path (supplied from the inter-mesenteric plexus, the renal plexus and the lumbar sympathetic trunk) converging towards the inferior mesenteric plexus and ganglia, relay that specifically distributes fibers along the vascular path of the testicular artery. We consider that the term “spermatic” attributed to that ganglion must be rather understood as referring to its vascular relation with the origin of the testicular (spermatic) artery than as mainly related (macroscopically) to its gonadal distribution.

Even though in humans there was paid little attention to the SG, in mammals there are several reports dealing with that distinctive structure [8, 9]. The efferent nerve supply of the mammalian testis is partly derived from sympathetic neurons in spermatic ganglia that distribute fibers through the superior spermatic nerve [9]. We evaluate our results as the first-time evidence of

the sympathetic (catecolaminergic) nature of the SG in humans.

The ganglionic stimulation of the autonomic system clearly participates in testosterone release from the testis [1], but this effect depends on the ganglion involved. There are evidences that neurons from the pelvic ganglia, rather than those from the para-aortic and spermatic ganglia, are the dominant source of efferent postganglionic fibers that supply the testis of the adult rat [9]. Also, it was demonstrated that the inferior mesenteric ganglion rather than the superior one influences the testosterone secretion of the testis. As for the human testis, tyrosine hydroxylase- and neuropeptide Y-positive nerves were found between seminiferous tubules and around blood vessels [10]. With these considerations it seemed reasonable to us to speculate that the SG may influence the testis via the longitudinal autonomic path (visceral path) while the testicular artery may be kept as the scaffold for a vascular distribution of the ganglion (vascular path).

Ganglia of the peripheral nervous system outside of the normally found autonomic and dorsal root varieties have been described and termed “*pseudoganglia*”, but little attention has been placed on the histology of these focal swellings [11]. Previous studies evaluated the phrenic ganglion histology and immunohistochemistry [11, 12]; we bring here evidences that add the spermatic ganglion to the phrenic ganglion in the group of the abdominal para-aortic catecolaminergic pseudoganglia.

## Conclusions

Further tracing studies must be performed in order to evaluate the exact distribution of the spermatic ganglion, in order to evaluate its function.

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