Surgical and Radiologic Anatomy (2019) 41:973–976
https://doi.org/10.1007/s00276-019-02180-4

ANATOMIC VARIATIONS

Accessory right spermatic ganglion: possible embryological basis and clinical significance

Shiva M. Nair[1] · Nicholas E. Power[1] · Tyler S. Beveridge[2]

Received: 6 September 2018 / Accepted: 3 January 2019 / Published online: 28 February 2019

Abstract
The spermatic ganglia are collections of sympathetic neuron cell bodies located within the cords of the infrarenal aortic plexus, positioned at the origin of the testicular arteries in males. During routine dissection of the aortic plexus at our institution, one specimen exhibited a second (accessory) testicular artery on the right side that coursed retrocaval. Histology was used to confirm the presence of an accessory right spermatic ganglion at the base of the accessory retrocaval testicular artery. Interestingly, the accessory spermatic ganglion was also supplied by its own right lumbar splanchnic nerve. This is the first case to describe the anatomy of an accessory spermatic ganglion in a specimen that exhibits an accessory testicular artery on the right side. This neurovascular variation is of interest to surgeons who aim to perform nerve-sparing retroperitoneal lymph node dissections for malignancy.

Keywords Accessory testicular artery · Accessory spermatic ganglion · Sympathetic chain · Retroperitoneal lymph node dissection · Nerve-sparing

Introduction

The spermatic ganglia are the superior constituent ganglia of the aortic plexus [1, 10]. Located near the origin of the testicular arteries in males, the spermatic ganglia are supplied by the first (most superior) infrarenal lumbar splanchnic nerve joining the aortic plexus [1, 6]. Additionally, they may also receive neural fibers by way of intermesenteric nerves from the aorticorenal/superior mesenteric plexuses [1, 10]. These ganglia are recognizable by their distal branches extending along the testicular arteries to comprise the spermatic plexus. The spermatic ganglia also exhibit an inferior branch that extends caudally along the abdominal aorta towards the inferior positioned, prevertebral ganglia of the aortic plexus; the inferior mesenteric ganglion on the left and prehypogastric ganglion on the right [1]. The topographical location of the spermatic ganglia is achieved during embryogenesis. At this time, the neural crest cells (primitive post-ganglionic neurons) delaminate from the dorsal neural tube and migrate ventrally towards the developing dorsal aorta [3, 5, 13]. Although several chemotactic factors have been identified that mediate this process, the exact mechanisms behind the morphogenesis of the spermatic ganglia, specifically, remain unclear. In the present case report, a previously unreported variation in the anatomy of the right spermatic ganglion is discussed that provides insight into the complex migratory mechanisms driving the development of these structures. Here, we present data from a dissection of a fresh-frozen human cadaver that exhibited an accessory spermatic ganglion positioned at the origin of an accessory retrocaval testicular artery on the right side.

Case report

During routine dissection of the infrarenal aortic plexus on a fresh-frozen, 65-year-old male cadaver (history: myocardial infarction), an accessory retrocaval testicular artery in addition to the testicular artery proper on the right side was observed (Fig. 1). The right testicular artery proper was

✉ Tyler S. Beveridge
tbeverid@uwo.ca

[1] London Health Sciences Centre, Urology Division, Department of Surgery, Schulich School of Medicine and Dentistry, University of Western Ontario, London, ON, Canada

[2] Department of Anatomy and Cell Biology, Schulich School of Medicine and Dentistry, University of Western Ontario, London, ON N6A 3K7, Canada

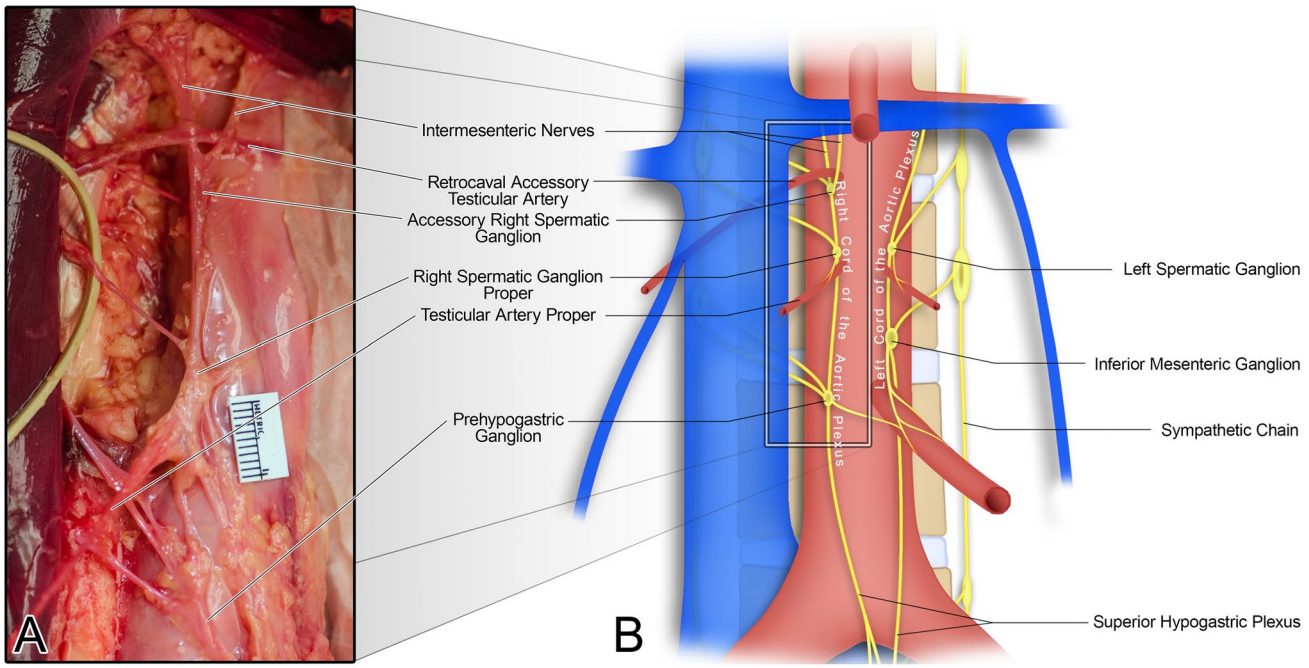

Fig. 1 **a** Photograph showing an anterior view of the aortic plexus in a specimen exhibiting an accessory, retrocaval testicular artery on the right side. Interestingly, the accessory testicular artery was accompanied by an accessory right spermatic ganglion, supplied by a unique accessory lumbar splanchnic nerve from the first infrarenal lumbar sympathetic chain ganglion (not visible). **b** Schematic showing accessory sympathetic ganglion and sympathetic pathways

defined as the vessel that was more closely paired to the left testicular artery. The accessory right testicular artery was located 2.9 cm superior to the origin of the testicular artery proper, just inferior to the crossing of left renal vein over the aorta. The accessory testicular artery coursed retrocaval before pairing with the testicular vein and testicular artery proper, lateral to the inferior vena cava.

At the base of both right testicular arteries, within the right cord of the aortic plexus, was an observable swelling of nervous tissue. Both swellings were excised to undergo histological analysis to verify their characterization as sympathetic ganglia. Hematoxylin and eosin (H&E) staining of this tissue demonstrated the presence of neuronal cell bodies containing abundant lipofuscin granules, surrounded by irregularly arranged satellite cells (Fig. 2b, c). Additionally, immunohistochemical staining for both specimens was tyrosine hydroxylase positive thus confirming their sympathetic nature (Fig. 2d–g). The identified ganglia were further characterized as accessory/proper spermatic ganglia given their association with the respective right testicular arteries. Each spermatic ganglion was supplied by a separate lumbar splanchnic nerve; however, both lumbar splanchnic nerves originated from one unified lumbar sympathetic chain ganglion (Fig. 1b).

As expected, inferior to the right spermatic ganglion proper, the prehypogastric ganglion was identified as a distinct structure supplied by the lumbar splanchnic nerves branching from the second infrarenal lumbar sympathetic chain ganglion. The anatomical arrangement of the accessory right spermatic ganglion, right spermatic ganglion proper, and the prehypogastric ganglion within the right cord of the aortic plexus is shown in Fig. 1.

Discussion

The present paper describes a specimen that exhibited an accessory right spermatic ganglion at the origin of an accessory retrocaval testicular artery on the right side. The development of an accessory retrocaval testicular artery is not an unusual vascular variation given the previous reports of—and embryological rationales behind—the development of accessory testicular arteries [2, 8, 11] or retrocaval testicular arteries [6, 9, 10]. However, the present report also describes the anatomy of an accessory spermatic ganglion, positioned at the origin of the accessory testicular artery; a previously unreported finding that supports a possible embryological association between the developing testicular arteries and the migration of the sympathetic neurons that form the spermatic ganglia.

In embryological development, the migration of the neural crest cells from the dorsal neural tube during the 4th and 5th week of embryogenesis give rise to the sympathetic chain ganglia and the prevertebral ganglia [3, 5,

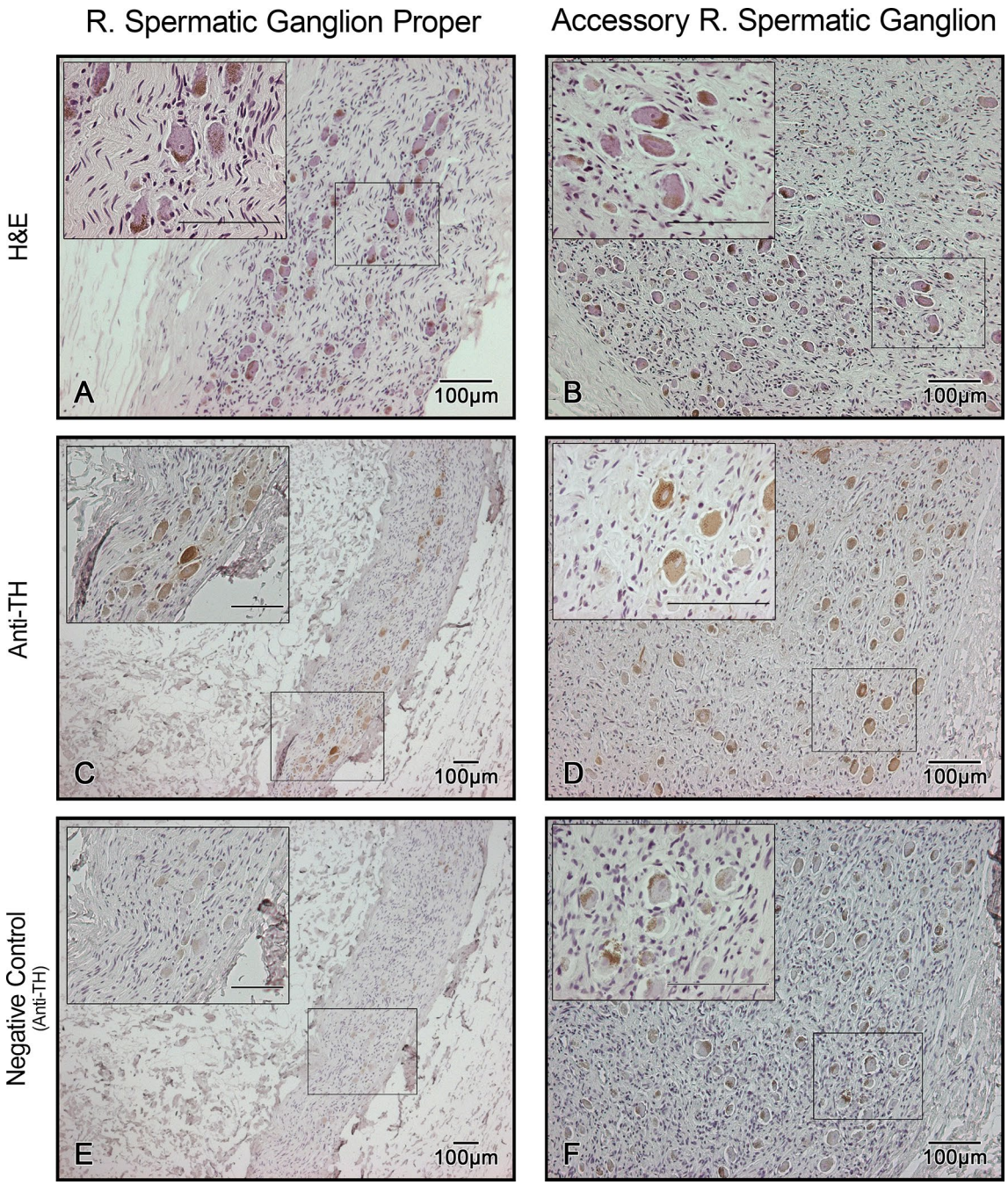

Fig. 2 **a** H&E staining from the right spermatic ganglion proper. **b** Hematoxylin and eosin (H&E) staining from the accessory right spermatic ganglion. **c** Anti-tyrosine hydroxylase immunostaining from the right spermatic ganglion proper. **d** Anti-tyrosine hydroxylase immunostaining from the accessory right spermatic ganglion. **e, f** Negative controls for immunostaining, respectively

13]. Bone morphogenic proteins from the developing dorsal aorta mediate this process by inducing the production of specific chemoattractant factors in the para-aortic region [12]. Several factors have been identified to understand the aggregation of neurons into compact masses or ganglia in the developing sympathetic chain, although the precise morphogenesis of the prevertebral ganglia is less understood [5].

A cadaveric study by Motoc et al. [10] suggested that the topographical position of the spermatic ganglia may not be completely influenced by the origin of the testicular arteries. This was supported by their observation of the left spermatic ganglion in the expected location within the aortic plexus during the dissection of a specimen that exhibited a left testicular artery originating from the left renal artery rather

than the abdominal aorta [10]. In contrast, the present case supports the theory that there is a developmental association between the testicular arteries and the spermatic ganglia. Specifically, the observation of an accessory testicular artery associated with the development of an accessory spermatic ganglion supports the well-established understanding that the major prevertebral ganglia (i.e., the celiac, superior mesenteric, aorticorenal, and inferior mesenteric ganglia) develop around the origin of the abdominal aortic branches. Therefore, we theorize that the developing branches of the abdominal aorta (embryologic splanchnic and vitelline arteries) play a role honing the migration of the neural crest cells with a prevertebral fate, by adjusting the distribution of the chemotactic factors initially mediated by the dorsal aorta; the outcome, facilitating congregation around the origin of arterial branches. This suggestion is further supported by unpublished data from Schwarz in 2008, who observed ectopically positioned sympathetic ganglia closely associated with blood vessels in Neuropilin-1 knockout embryos [7]. The authors suggest that their observation of vascular-associated, ectopic aggregations of sympathetic neurons in embryos with inhibited gangliogenesis may suggest underlying migratory signals from blood vessels. It is also plausible that chemotactic factors that promote angiogenesis may also influence gangliogenesis. To explore these theories, future embryological studies elucidating how these developing arteries may alter migratory signaling in the para-aortic mesenchyme are needed.

Clinically, the preservation of sympathetic plexuses during retroperitoneal lymph node dissection for germ cell testicular tumors, is associated with preservation of ejaculatory function [4]. Thus, it is important to understand that presence of accessory aortic branches is related to supernumerary sympathetic ganglia. Although, it is unclear whether preservation of these additional ganglia would lead to a significantly improved functional outcome, the surgical principle of minimal damage to the sympathetic plexuses during nerve preservation would apply.

In conclusion, the present report of accessory spermatic ganglia associated with accessory testicular artery suggests that the morphology of the aortic plexus may be predicted based on the anatomy of the arterial branches. Clinicians operating on the retroperitoneal space, especially performing nerve-sparing retroperitoneal lymph node dissection, can utilize this when planning surgery with radiological imaging.

Acknowledgements The authors would like to thank the donor and his family, because without their generosity this research would not be possible; the supervisors of the HAASE anatomy lab at Western University, Haley Linklater and Kevin Walker, for their help with the cadaveric dissections; and Dr. Brian L. Allman for his continued advice, mentorship and revisions to the manuscript.

Author contributions SMN: data analysis and interpretation, drafting the manuscript, critical revision of the figures. NEP: data analysis and interpretation, critical revision of the figures, critical revision of the manuscript, supervision. TSB: conception, data collection, data analysis and interpretation, drafting the manuscript, figure illustration.

Compliance with ethical standards

Conflict of interest The authors have no conflict of interest with the content of the manuscript, nor any financial disclosures to report.

Ethical approval This work was undertaken in accordance with the University of Western's Committee for Cadaveric Use in Research [approval #15052013].

References

1. Beveridge TS, Johnson M, Power A, Power NE, Allman BL (2015) Anatomy of the nerves and ganglia of the aortic plexus in males. J Anat 226(1):93–103. https://doi.org/10.1111/joa.12251
2. Deepthinath R, Satheesha N, Mehta R, Bhat S, Rodrigues V, Samuel V, Venkataramana V, Prasad A (2006) Multiple variations in the paired arteries of abdominal aorta. Clin Anat 19(6):566–568. https://doi.org/10.1002/ca.20207
3. Huber K (2006) The sympathoadrenal cell lineage: Specification, diversification, and new perspectives. Dev Biol 298(2):335–343. https://doi.org/10.1016/j.ydbio.2006.07.010
4. Jewett MA, Groll RJ (2007) Nerve-sparing retroperitoneal lymphadenectomy. Urol Clin N Am 34(2):149–158. https://doi.org/10.1016/j.ucl.2007.02.014
5. Kameda Y (2014) Signaling molecules and transcription factors involved in the development of the sympathetic nervous system, with special emphasis on the superior cervical ganglion. Cell Tissue Res 357(3):527–548. https://doi.org/10.1007/s00441-014-1847-3
6. Kayalvizhi I, Narayan R, Kumar P (2017) Anatomical variations of testicular artery: a review. Folia Morphol (Warsz) 76(4):541–550. https://doi.org/10.5603/FM.a2017.0035
7. Lumb R, Schwarz Q (2015) Sympathoadrenal neural crest cells: the known, unknown and forgotten? Dev Growth Differ 57(2):146–157. https://doi.org/10.1111/dgd.12189
8. Mazengenya P (2015) Multiple variations of the renal and testicular vessels: possible embryological basis and clinical importance. Surg Radiol Anat. https://doi.org/10.1007/s00276-015-1584-7
9. Mirapeix RM, Sañudo JR, Ferreira B, Domenech-Mateu JM (1996) A retrocaval right testicular artery passing through a hiatus in a bifid right renal vein. J Anat 189(3):689–690
10. Motoc A, Rusu MC, Jianu AM (2010) The spermatic ganglion in humans: an anatomical update. Rom J Morphol Embryol 51(4):719–723. (**510410719723 [pii]**)
11. Nayak SR, Jiji P, D'Costa S, Prabhu L, Krishnamurthy A, Pai M, Prakash (2007) Multiple anomalies involving testicular and suprarenal arteries: embryological basis and clinical significance. Rom J Morphol Embryol 48(2):155–159
12. Saito D, Takase T, Murai H, Takahashi Y (2012) The dorsal aorta initiates a molecular cascade that instructs sympatho-adrenal specification. Science 336:1578–1581. https://doi.org/10.1126/science.1222369
13. Takahashi Y, Sipp D, Enomoto H (2013) Tissue interactions in neural crest cell development and disease. Science 341(6148):860–863. https://doi.org/10.1126/science.1230717