VIA MEDICA

REVIEW ARTICLE

Vol. 76, No. 4, pp. 541–550
DOI: 10.5603/FM.a2017.0035

ISSN 0015–5659
www.fm.viamedica.pl

Anatomical variations of testicular artery: a review

I. Kayalvizhi, R.K. Narayan, P. Kumar

Department of Anatomy, Pandit Bhagwat Dayal Sharma Pgims, Rohtak, Haryana, India

[Received: 30 November 2016; Accepted: 9 March 2017]

The testicular arteries (TAs) also known as internal spermatic arteries are long and slender arteries usually arising from the anterolateral aspect of the abdominal aorta, 2.5 cm to 5 cm caudal to the renal arteries. The variation in TAs may be found with respect to their origin, number or course. They can originate from the abdominal aorta itself at an abnormal level. If not arising from abdominal aorta the TA variants may arise from renal artery, suprarenal artery or any one of the lumbar arteries. Rarely it can arise from common or internal iliac artery, or from the superior epigastric artery. The most common variation with respect to origin of TA was found in association with renal vessels. In regard to their number, double TA was found to be most common and with respect to course most common variation was arched TA over ipsilateral renal vein. The arched TA at times on right side had a retrocaval course. Occurrence of TA variants is explained with embryology and the knowledge of its clinical significance is essential for future surgeons for designing vascular surgeries. Four studies had attempted to classify TA variants regarding their origin, number and course but they could not accommodate recently found TA variants. This led to our new proposed classification. (Folia Morphol 2017; 76, 4: 541–550)

Key words: testicular artery, testicular artery variants, accessory testicular artery, arched testicular artery, retrocaval testicular artery

INTRODUCTION

The testicular arteries (TAs) also known as internal spermatic arteries are long and slender arteries usually arising from the anterolateral aspect of the abdominal aorta (AA), 2.5 cm to 5 cm caudal to the renal arteries (RA) but above the origin of the inferior mesenteric artery. They are directed under the parietal peritoneum over the psoas major muscle. The right TA after crossing the inferior vena cava (IVC) lies posterior to the horizontal part of the duodenum, right colic and ileocolic arteries, root of the mesentery and terminal ileum, whereas the left TA lies posterior to the inferior mesenteric vein, left colic artery and descending colon. TA crosses the ureter, supplies its middle portion and runs along the pelvic brim above the external iliac artery. It enters the deep inguinal ring and passes in the spermatic cord to the testis. In the abdomen, the TA supplies the peri-renal fat, ureter and iliac lymph nodes. In the inguinal canal it supplies the cremaster muscle [36, 68].

Arterial variations arising from AA are quite common and are frequently reported. Out of all paired and unpaired branches of AA the variations are common in RA and comparatively less reported in gonadal

Address for correspondence: Prof. I. Kayalvizhi, Department of Anatomy, Pandit Bhagwat Dayal Sharma Pgims, Rohtak 124001, Haryana, India, e-mail: drkayalvizhi3@gmail.com

arteries. In the recent studies, the percentage of single RA was reported to be 70%, of double RA — 25% and of persisting third RA it was 2.6% [22]. In majority, the initial studies of TA variants reported were of those investigators who worked on renal vessels and incidentally found TA anomalies [2–4, 37, 54]. A few studies were therefore conducted in 20th century using cadavers and were reported [5, 21, 42–44, 46]. In recent years most of the studies published were case reports of TA variants.

The variation in TAs may be with respect to their origin, number or course. They may originate from the AA itself at an abnormal level. If not arising from AA, the TA variants may arise from RA, supra RA or any one of the lumbar arteries. Rarely it can arise from common or internal iliac artery, or from the superior epigastric artery [9, 23]. The most common variation with respect to origin of TA was found in association with renal vessels. In regard to numbers, double TA was most common and with respect to course most common variation was arched TA over ipsilateral renal vein. The arched TA at times on right side had a retrocaval course.

Various authors had used different types of specimen to study the variations of TAs. Most of the authors had studied on human adult cadavers used during medical curriculum [8, 41]. A study was conducted using angiography in living human beings [63]. Felix (1912) [16] utilised foetuses to study on the embryological perspective, whereas Machnicki and Grzybiak (1997) [32] and Cicekcibasi et al. (2002) [14] used foetuses to analyse TA variants.

Four studies have attempted so far to classify all the variations of TA [14, 32, 43, 55]. Notkovitch [43] classified the variations on the basis of TA course in relation to renal pedicle. Classification described by Radojevic and Stolic [55] has not gained any importance. Machnicki and Grzybiak [32] and Cicekcibasi et al. [14] classified according to the origin and number of TA variants. All these authors classified the TA variants which were observed in their studies and did not include other possible variations in their classification. As there are existing lacunae in classification of these variants from reported data, there is a need for a new classification.

Awareness of these variations in origin of the arteries around renal, hilar and para-aortic region is of utmost importance and help in designing microvascular surgeries.

The aim of our review article is to summarise the topography of TA variants with respect to origin, number and course and finding necessary explanation for the above variants with the help of embryology using the various reported data.

DISCUSSION

Anomalies of TA with respect to origin, number and course were discussed individually with the existing literature. The embryological basis of these variations was also discussed in brief.

Testicular artery variants: with respect to site of origin

Testicular artery variants: origin from AA. According to Adachi [2], supra RA and TA took origin from aorta as a common trunk in 1 out of 26 suprarenal glands. Such a variation was also noted by Sheheta [61]. Shinohara et al. [62] reported a case where origin of TA was cranial to inferior phrenic artery and it was reported to be the highest level of origin during that time. Brohi et al. [12] described a case of left TA which took origin at the level of ipsilateral RA. Onderoglu et al. [46] reported a right TA originating from aorta at the level of RA and his finding was supported by Xue et al. [69]. Ozan et al. [48] described that TA originated from AA at the level of SMA on both sides. Machnicki and Grzybiak [32] examined variations in both foetuses and adults. Majority of the variations in origin of TAs were found to be from AA at the level of RA or proximal and distal to it. Distal to normal level of TA origin, the various sites of origin encountered were close to inferior mesenteric or common iliac.

Testicular artery variants: origin from other sites. If the TA is not arising from AA the frequent sites of origin were from main renal trunk, accessory RAs and segmental arteries. Rarely, few reports were found where TA variants arise from hilar branch of main renal trunk, aberrant RA, polar arteries and capsular arteries. There was a single case report for TA variant taking origin from inferior epigastric and external iliac.

The reports of major studies by various authors who had worked using cadavers and live angiography patients were tabulated and the incidences of TA variations on right and left sides were calculated (Table 1). It was observed that there were no significant side differences.

Testicular artery variants: accessory TAs

The presence of double/accessory/duplicated TA reported till date have been tabulated and shown

Table 1. Incidence of testicular arteries origin variations

Authors	Body	Sample	Variation	%	Right	Left
Notkovitch		405		14		
Notkovitch (1956)	50	100	10	10	2	8
Harrison and McGregor	129	258	1	0.4	1	
Merklin and Michaels		185		15		
Onderoglu et al.	66	132	1	0.76	1	
Asala	150	300	5	1.66	5	
Cicekcibasi et al.		90	11	12.2	7	4
Naito (2006)	59	118	4	3.39		4
Bordei			12		3	9
Shoja	50	98	14	14.3	11	3
Pai et al.	34	68	9	13.2	4	5
Bandopadhayay and Saha	80	160	3	1.8		3
Wadhwa and Soni (2010)	30	60	5	4.2	2	3
Gupta et al.	30	60	4	8.4	2	2
Mamatha et al. (2015)	40	80	7	8.75	2	5
Total		2114	86	4.1	40 (1.9%)	46 (2.2%)

in Table 2. In this table our proposed classification types have been introduced (vide infra). There was no consistency in the terminology of accessory TAs. Wherever there was duplication of TA, majority of the authors termed one of them as main and the other as accessory TA. Some authors termed them as superior and inferior whereas others marked them as medial and lateral TAs. To have a common terminology for describing these accessory TAs in future it may be named as medial and lateral TAs. All other nomenclature for accessory TAs should be dropped to avoid confusion. In case of accessory TA, if both arteries arise from different sites, then it's quite easy to identify them as medial or lateral according to their site of origin; for example, if one of the two TAs normally arise from AA and the other from renal pedicle, then the former will be referred as medial and the latter would be termed as lateral TA. If both TAs arise from same site (both from AA or from the renal pedicle), then the medial and lateral TA would be decided by seeing the further course of both these arteries.

Majority of the reports with respect to finding of accessory TAs were case reports from their respective geographical areas. Most of the accessory TAs belong to type IB and type IIA, B and C of our classification; which means these accessory TAs arise from AA at RA level or from renal pedicle and its branches. There was no marked difference in incidence of variations with respect to right or left sides. All the accessory TAs' reports were in majority unilateral except by Rusu [58], Filipovic et al. [17] and Paraskevas et al. [53], who have reported bilateral accessory TAs. There was no report in literature regarding more than two TAs on one side. Neither triple nor quadruple TA variants were found in literature, as described by Hollinshead [23] and Bergman et al. [9].

General classification

While going through the literature, we have come across various studies as well as case reports sharing the knowledge regarding these variants and to have a proper understanding of these variations it needs to have a proper classification. So far four authors have attempted to classify these variants.

Classification by origin: TA variants by Radojevic and Stolic [55]. Radojevic and Stolic [55] submitted their classification of TA variations to the Association of Anatomists in 1964 based on their research over 150 dissections. They classified these variations in four groups: Type I, the most frequent, in which the TA arises from the aorta, sometimes at the same level as the RA, sometimes lower down between it and the superior mesenteric artery; Type II (about 5%) in which the TA arises from the RA itself or from a supernumerary artery

Table 2. Accessory testicular artery

Author [reference]	Year	Sides	Medial TA (M)	Lateral TA (L)	Right (according to our proposed classification)		Left	
					M	L	M	L
Anson and Kurth [3]	1955	Left	Doubling of TA	Doubling of TA				
Bergman et al. [7]	1992	Right	From inferior polar artery 1 cm distal to its origin from AA	Mid-point of accessory RA	IID	IIB		
Asala et al. [5]	2001	Right	From AA	From AA at level of SMA	IA	IC		
Cicekcibasi et al. [14]	2002	Right	From AA	From AA	IA	IA		
		Right	From AA	From SRA	IA	III		
Loukas and Stewart [31]	2004	Left	From AA inferior to the SMA	From AA between SMA and left RV			IB	IB
Deepthinath et al. [15]	2006	Left	From accessory RA	From RA			IIB	IIA
Rusu [58]	2006	Right	From AA	From superior RA	IA	IIA		
		Left	From AA (both medial and lateral as common trunk)	From AA			IA	IA
Bordei [11]	2007	Left	From RA	From RA			IIA	IIA
		Left	AA 2 cm below RA	Accessory RA			IB	IIB
		Left	From AA close to RA	From artery of anteroinferior segment (branch of RA)			IB	IIE
Pai et al. [50]	2008	Right	From AA immediately below RA as common trunk with inferior SRA and renal capsular artery	Prehilar right RA	IB	IIA		
Gurses et al. [20]	2008	Right	From AA inferior to the SMA	From lower accessory RA	IB	IIB		
Soni and Wadhwa [65]	2010	Left	From AA	From lower accessory RA			IA	IIB
Kayalvizhi et al. [26]	2011	Left	From AA	From AA above renal pedicle			IA	IB
Jyothsna et al. [25]	2012	Left	From AA, 3 cm proximal to inferior mesenteric	From AA below left RA			IA	IB
Filipovic et al. [17]	2012	Left	Accessory RA	Common trunk from AA with inferior SRA			IIB	IB
Paraskevas et al. [53]	2014	Right	From AA	From right RA	IA	IIA		
		Left	From AA	From AA proximal left RA			IA	IB

AA — abdominal aorta; RA — renal artery; SRA — suprarenal artery; RV — renal vein; SMA — superior mesenteric artery

without actually arising from a true polar artery; Type III (2%), in which the origin is from the middle suprarenal artery; Type IV (2.6%), where the artery originated just below the RA to pass above and anteriorly, over the renal vein. This classification was mentioned by only one author, i.e. Ravery et al. [57], and is no more in use and not much discussed in literature.

The other three authors whose classifications were used recently are Notkovitch (1956) [43], Machnicki and Grzybiak (1997) [32] and Cicekcibasi et al. (2002) [14]. Details of these three classifications are:

Classification by origin of TA as described by Notkovitch [43]. Notkovitch [43] classified TAs into three principal types on the basis of the course followed by them: Type I, the gonadal artery descends directly without contact with the renal vein; Type II, the gonadal artery arises from a higher level than the renal vein and crosses in front of it and Type III,

Table 3. Proposed classification of testicular artery variants regarding origin

I. FROM ABDOMINAL AORTA		II. FROM RENAL TRUNK		III. FROM SUPRARENAL BRANCH	IV. OTHER BRANCHES
IA	**Normal origin**	**IIA**	**From main trunk/hilar**		
IB	**Around renal pedicle**	**IIB**	**From accessory renal branch**		
	Corresponding to pedicle		Superior/first accessory renal artery		
	Proximal to pedicle		Inferior/second accessory renal artery		
	Distal to pedicle		Most inferior/third accessory renal artery		
IC	**At and between superior mesenteric artery and coeliac trunk**	**IIC**	**From aberrant renal branch**		
ID	**At and distal to inferior mesenteric artery level**	**IID**	**From polar/capsular branch**		
			Superior branch		
			Inferior branch		
		IIE	**From segmental branch**		
			Superior segmental branch		
			Inferior segmental branch		

the gonadal artery arises from a lower level than the renal vein and arches around it.

Classification by origin and number of TA as described by Machnicki and Grzybiak [32]. Machnicki and Grzybiak [32] included TAs from both foetuses and adults. The authors grouped them according to their origin and number into four major types: Type A — a single TA originating from the aorta; Type B — a single TA originating from the RA; Type C — two TA originating from the aorta that supplied the same gonad; Type D — two TA supplying the same gonad, one arising from the aorta and the other from the RA.

Classification by origin and number of TA as described by Çiçekcibasi et al. [14]. Çiçekcibasi et al. [14] classified the variations into four alternative types on the basis of their origin and number: Type I — TA arising from the suprarenal artery; Type II — TA originating from the RA; Type III — TA of high positional origin from the AA, close to the RA lineage; Type IV — TA duplication originating from the aorta or from various vessels.

Regarding these existing classifications there was a lot of deviation from one author to the other and still all these classifications were found incomplete, as many reports and studies have observations which do not fit into any of these classified categories, such as origin from accessory RA or segmental branches of RA. Many such reports have come to light in recent years so it is a high time for a new classification which will include all the various cases of TA variants.

Proposed classification

Considering all the above points, an attempt was made to put forward a new classification on the basis of site and level of origin of TA. The variants were classified into four major types: Type I, where the TA arises from any part of AA; Type II, where renal pedicle and its associated arteries give rise to TA; Type III, where TA arises from supra-RAs and Type IV, where TA arises from all the other sites like common iliac artery, external or internal iliac artery, epigastric artery, thoracic aorta and any other probable sites. These major four types are further classified into subtypes as shown in Table 3. An attempt was also made utilising the published data to place them under our classification as shown in Table 4.

Incidences of origin of TAs in association with RA

Testicular artery may arise from RA, from its main trunk or from the accessory RA. The reports of all the authors, who provided data regarding incidences in relation to RA, were compiled and tabulated; incidence reported was calculated and converted to percentage for statistical purpose. The least incidence was reported by Harrison and McGregor [21] (0.40%) and the highest by Adachi [2] (16.33%) — as quoted in Paraskevas et al. (2014) [53]. Pick and Anson [54] observed very high incidence of variations in their study (16.10%). They also noted incidence of variations on both right and left sides to be 6.1% and 10%, respectively, as found quoted in Gupta et al. (2011) [19] (Table 5).

Table 4. Proposed classification of testicular arteries variants regarding origin (numbers in the table correspond to the reference article

I. FROM ABDOMINAL AORTA		II. FROM RENAL TRUNK		III. FROM SUPRARENAL BRANCH (5/210)*	IV. OTHER BRANCHES (5/84)*
IA	**Normal origin (ATA)**	**IIA**	**From main trunk/hilar** (15/366)*	[2, 14, 67]	[24, 33, 35]
	[18, 43]		[11, 19, 45, 50, 51, 63, 66, 67]		
IB	**Around renal pedicle** (25/1236)*	**IIB**	**From accessory renal branch** (16/166)*		
	Corresponding to pedicle (16/988)*		Superior/first accessory renal artery (6/98)*		
	[5, 11, 12, 14, 21, 34, 40, 46, 50, 60, 69]		[11, 33, 45, 63, 64]		
	Proximal to pedicle (2/4)*		Inferior/second accessory renal artery (9/36)*		
	[27, 29, 52]		[11, 19, 20, 63, 66]		
	Distal to pedicle (7/244)*		Most inferior/third accessory renal artery (1/16)*		
	[6, 10, 11, 19, 28, 38, 41]		[11]		
IC	**At and between SMA and CT** (3/6)*	**IIC**	**From aberrant renal branch** (1/2)*		
	[48, 62, 64]		[59]		
ID	**At and distal to IMA level**	**IID**	**From polar/capsular branch** (12/162)*		
	None		[14, 50, 56, 57]		
		IIE	**From segmental branch** (5/34)*		
			Superior segmental branch (1/16)*		
			[11]		
			Inferior segmental branch (4/18)*		
			[1, 62, 63]		

ATA — arched testicular artery; SMA — superior mesenteric artery; IMA — inferior mesenteric artery; CT — coeliac trunk; *(A/B): A — number of variation found; B — total number of samples studied

Table 5. Prevalence of testicular arteries in relation to renal artery

Authors (reference)	Quoted in	No. of dissections	Left (% or cases)	Right (% or cases)	Total (%)
Adachi (1928) [2]		–	–	–	16.33%
Cauldwell and Anson (1936) [13]		–	–	–	10%
Pick and Anson (1941) [54]	Gupta et al. (2011)	50	10%	6.10%	16.10%
Anson and Kurth (1955) [3]	Paraskevas et al. (2014)	–	–	–	3%
Notkovitch (1956) [43]		100	8.10%	6.50%	14.50%
Harrison and McGregor (1957) [21]		–	–	–	0.40%
Merklin and Michaels (1958) [37]	Ozan et al. (1995)				15%
Lippert and Pabst (1985) [30]	Paraskevas et al. (2014)	–	4.00%	6.00%	10.00%
Bergman et al. (1988) [8]	Paraskevas et al. (2014)				15%
Onderoglu et al. (1993) [46]		125	–	0.76%	0.76%
Asala et al. (2001) [5]		150	–	–	2.60%
Cicekcibasi et al. (2002) [14]		–	–	–	5.50%
Soni and Wadhwa (2010) [65]		60	6.60%	3.30%	10.00%
Shoja et al. (2007) [63]		98	3%	11%	14.00%
Pai et al. (2008) [50]		68	2.90%	5.90%	8.80%
Gupta et al (2011) [19]		60	3.30%	3.30%	6.60%
Panyanetinad (2011) [51]		1	–	1 case	–
Singh et al. (2011) [64]		1	–	1 case	–
Paraskevas et al. (2014) [53]		1	–	1 case	–
Mamatha et al. (2015) [33]		40	10%	2.50%	12.50%

Table 6. Authors reporting arching of testicular artery and its retrocaval course

Authors reporting arching of testicular artery	Notkovitch (1956), Grine and Kramer, Satheesha, Lelli et al., Naito (2006), Acar et al., Pai et al., Bandopadhayay and Saha (2009), Mamatha (2010), Jyothsna et al., Salve et al., Wadhwa and Soni, Singh et al., Gupta et al., Nathan et al.
Authors reporting retrocaval course of testicular artery	Asala et al., Xue et al., Bhaskar et al., Lelli et al., Gurses et al., Li et al., Otulakowski and Woźniak, Ozdemir et al.

Table 7. Prevalence of arched testicular artery

Authors (reference)	No. of cases	Left	Right
Pick and Anson (1940) [54]	194	2%	None
Notkovitch (1956) [43]	183	20.3%	8%
Naito et al. (2006) [39]	59	6.7%	None
Bandopadhayay and Saha (2009) [6]	80	3.8%	None
Soni and Wadhva (2010) [65]	30	1.7%	None
Gupta et al. (2011) [19]	60	3.3%	None

Prevalence of arched TA

The arched TA can arise from these three sites. The sites can be either from aorta at normal level of origin or at and distal to the level of renal pedicle. During its course in majority instead of descending downwards it ascends upwards to lie behind the renal pedicle. Due to this variation complications occur on both sides. If on left side, then the ascended TA arch loops or hooks the renal vein and then descends anterior to it to follow a normal course which results in arched TA on left side. In the case of right side, the TA plays an important role with IVC. Majority of time it runs anterior to IVC and then further with renal pedicle to follow a normal course. But in some cases instead of running anterior to IVC it follows a retrocaval course and lies posterior to renal pedicle to arch the right renal vein and then to descend and follow a normal course. This pattern is called as retrocaval arched TA on right side. The authors who have contributed to arched and retrocaval TA are listed in Table 6 and the incidences in their study are tabulated in Table 7.

Embryology

Gonadal arteries (GAs) develop as lateral persistent splanchnic branches of aorta that enters the mesonephros. These mesonephric arteries supply the developing gonads, suprarenal glands, diaphragm and the kidneys. When the sex gland arises, it is supplied by several branches of the mesonephric arteries cranial to the renal vascular pedicle. With the decent of the gland, new lower branches develop and at the same time higher branches atrophy. There are 9 lateral mesonephric arteries in early developing stages that are divided into three groups — cranial, middle and caudal. Although any of these 9 arteries may become the GA, it generally arises from the caudal group and the other middle and cranial groups of arteries disappear. If the caudal mesonephric arteries disappear and cranial or middle mesonephric arteries are persistent it may give rise to GA in adult anatomy. In the case of persistent middle mesonephric arteries, the arteries to gonad arise at the level of renal pedicle. If the cranial mesonephric artery persists, then the GA is at the level of superior mesenteric artery and coeliac trunk, which gives rise to high level origin of GA.

The embryological explanation for arched GA is as follows: If the persisting artery was situated cranial to renal pedicle (middle group of mesonephric arteries) then it will appear crossing in front of pedicle with the descent of gland and if kidney ascends still higher carrying its renal vein to a higher level than the origin of the GA, then the latter will be forced to follow an arched course around the vein as found.

The embryological explanation for GA arising from segmental RA is as follows: The middle group of lateral mesonephric arteries gives rise to the RAs. If one of the middle group of lateral mesonephric arteries splits into two branches distally and one of these branches supplies the genital ridge; the TA may arise from associated vascular tree of kidney (main trunk, hilar branch, segmental and associated anomalies).

The embryological explanation for retrocaval course of GA on right side depends on the development of IVC and its associated structures.

Clinical anatomy

The arterial pattern gains importance due to its variation in surgical anatomy. Especially regarding renal arterial variations, there were frequent incidences and these variations were also reported in association with TAs. The anomalies of TAs in association with RAs complicate surgery leading to fatal haemorrhage which could be avoided if the arterial pattern of that particular patient was understood prior to surgery using angiography for patients and normal living donor for renal transplantation. If any anomaly is detected with angiography, then tests like phlebography, magnetic resonance imaging and spiral computed tomography should be done before surgical handling to prevent post- or intraoperative complications. The surgeons performing nephron preserving surgery, renal transplantation, operative procedures for management of renal vascular hypertension, renal infarction, and tumours of kidney need to have knowledge regarding variational anatomy of renal and associated gonadal vessels.

The clinical implications of anomalies of TAs regarding origin, number and course are varicocele, hydronephrosis, nephroptosis or malrotation of kidney, renal arterial hypertension, infarction of kidney, testicular atrophy, arched TA or risk of haemorrhage during surgical procedures, segmental ischaemia of kidney, undescended testis etc.

Varicocele is a secondary condition caused by compression of renal vein by variant TA. Hydronephrosis occurs due to occlusion or compression of ureter during anomalous course of TA. Nephroptosis is malrotation of kidney which can result in anomalous origin and course of TA.

Renal arterial hypertension was due to constriction of RA resulting in renal ischaemia.

If there are any arterial variations, the risk of infarction in kidney increases during surgical interventions inadvertently done during renal and para-aortic surgeries.

Before performing renal surgical procedure clinicians should plan for renal and associated vascular anomaly to prevent any unforeseen complications.

CONCLUSIONS

Four studies have attempted to classify TA variants regarding their origin, number and course, but they could not include recently found TA variants. This led us to propose new classification.

Regarding accessory TA variants, medial and lateral terms were found suitable regarding description point of view.

Testicular artery anomalous origin was frequently found at the renal level of AA and from associated anomalous renal vessels. TA variants had no significant side difference for anomalous origin as well as for origin of accessory TAs. Concluding from this evidence, there is no preferable side for renal transplant.

Embryology plays a vital role in development of TA variants.

In majority of the cases with respect to the course, TA had arched gonadal arteries on both sides, which was clinically important. The effect of arched gonadal artery on the right side was severe at times due to retrocaval course which may lead to infarct or testicular dystrophy on the right side.

As per literature, associated renal anomalies were found in majority of cases (70%), whereas TA variants were less frequent (14%).

Acknowledgements

We are thankful to Dr. Usha Dhall, Ex-Professor, Department of Anatomy, PGIMS Rohtak who helped us in every stage of preparation of this manuscript.

REFERENCES

1. Acar HI, Yazar F, Ozan H. Unusual origin and course of the testicular arteries. Surg Radiol Anat. 2007; 29(7): 601–603, doi: 10.1007/s00276-007-0232-2, indexed in Pubmed: 17618401.
2. Adachi B. Das Arterien system der Japaner. Band II, Kyoto 1928: 88–89.
3. Anson BJ, Kurth LE. Common variations in the renal blood supply. Surg Gynecol Obstet. 1955; 100(2): 157–162, indexed in Pubmed: 13238169.
4. Anson BJ, Cauldwell EW, Pick JW, et al. The blood supply of the kidney, suprarenal gland, and associated structures. Surg Gynecol Obstet. 1947; 84(3): 313–333, indexed in Pubmed: 20284768.
5. Asala S, Chaudhary SC, Masumbuko-Kahamba N, et al. Anatomical variations in the human testicular blood vessels. Ann Anat. 2001; 183(6): 545–549, doi: 10.1016/S0940-9602(01)80064-9, indexed in Pubmed: 11766526.
6. Bandopadhyay M, Saha A. Three Rare Variations in the Course of the Gonadal Artery. Int J Morphol. 2009; 27(3): 655–658, doi: 10.4067/s0717-95022009000300006.

7. Bergman RA, Cassell MD, Sahinoglu K, et al. Human doubled renal and testicular arteries. Ann Anat. 1992; 174(4): 313–315, indexed in Pubmed:1416060.
8. Bergman RA, Thompson SA, Afifi AK, Saadeh FA. Compendium of human anatomic variations. Urban and Schwarzenberg, Baltimore, Munich 1988: 83–92.
9. Bergman RA, Thomson SA, Afifi AK. Catalog of human variation. Urban and Schwarzenberg, Baltimore 1984: 119.
10. Bhaskar PV, Bhasin V, Kumar S. Abnormal branch of the testicular artery. Clin Anat. 2006; 19(6): 569–570, doi: 10.1002/ca.20215, indexed in Pubmed: 16283661.
11. Bordei P, Şapte E, Iliescu D. The morphology and the surgical importance of the gonadal arteries originating from the renal artery. Surg Radiol Anat. 2007; 29(5): 367–371, doi: 10.1007/s00276-007-0224-2.
12. Brohi RA, Sargon MF, Yener N. High origin and unusual suprarenal branch of a testicular artery. Surg Radiol Anat. 2001; 23(3): 207–208, indexed in Pubmed: 11490935.
13. Cauldwell E, Anson B. The visceral branches of the abdominal aorta: Topographical relationships. Am J Anat. 2005; 73(1): 27–57, doi: 10.1002/aja.1000730103.
14. Ciçekcibaşi AE, Salbacak A, Seker M, et al. The origin of gonadal arteries in human fetuses: anatomical variations. Ann Anat. 2002; 184(3): 275–279, doi: 10.1016/S0940-9602(02)80126-1, indexed in Pubmed: 12056759.
15. Deepthinath R, Satheesha Nayak B, Mehta RB, et al. Multiple variations in the paired arteries of the abdominal aorta. Clin Anat. 2006; 19(6): 566–568, doi: 10.1002/ca.20207, indexed in Pubmed: 16283657.
16. Felix W. Manual of human embryology. Keibel F, Mall FP (eds). Lippincott, Philadelphia 1912: 820–825.
17. Filipovic B, Stijak L, Filipovic B. An unusual origin of the double left testicular artery in a male cadaver: a case report. J Med Case Rep. 2012; 6: 267, doi: 10.1186/1752-1947-6-267, indexed in Pubmed: 22938096.
18. Grine FE, Kramer B. Arched gonadal arteries in the South African negro. J Anat. 1981; 132(Pt 3): 387–390, indexed in Pubmed: 7298490.
19. Gupta A, Singal R, Singh D. Variations of Gonadal Artery: Embryological basis and clinical significance. Int J Biol Med Res. 2011; 2(4): 1006–1010.
20. Gurses IA, Kale A, Gayretli O, et al. Bilateral variations of renal and testicular arteries. Int J Anatom Variations. 2009; 2: 45–47.
21. Harrison RG, McGregor GA. Anomalous origin and branching of the testicular arteries. Anat Rec. 1957; 129(4): 401–405, indexed in Pubmed: 13533887.
22. He B, Hamdorf JM. Clinical importance of anatomical variations of renal vasculature during laparoscopic donor nephrectomy. OA Anatom. 2013; 1(3), doi: 10.13172/2052-7829-1-3-865.
23. Hollinshead WH. Anatomy for surgeons. Harper & Row, New York 1971: 579–580.
24. Huban TR, Prasanna LC, Kumar V, et al. Rare variation in the origin of left testicular artery from left external iliac artery: a case report. NUJHS. 2015; 5(1): 68–70.
25. Jyothsna P, Mohandas Rao Kg, Somayaji Sn, et al. Multiple vascular anomalies involving testicular, suprarenal arteries and lumbar veins. N Am J Med Sci. 2012; 4(3): 154–156, doi: 10.4103/1947-2714.93880, indexed in Pubmed: 22454832.
26. Kayalvizhi I, Monisha B, Usha D. Accessory left testicular artery in association with double renal vessels: a rare anomaly. Folia Morphol. 2011; 70(4): 309–311, indexed in Pubmed: 22117252.
27. Kocabiyik N, Yalcin B, Kilic C, et al. Accessory renal arteries and an anomalous testicular artery of high origin. Gulhane Med J. 2005; 47(2): 141–143.
28. Lelli F, Maurelli V, Maranillo E, et al. Arched and retrocaval testicular arteries: a case report. Eur J Anat. 2007; 11: 119–122.
29. Li J, Ren ZF, Sun T. Bilateral high origins of testicular arteries: a rare variant. Rom J Morphol Embryol. 2012; 53(2): 427–429, indexed in Pubmed: 22732819.
30. Lippert H, Pabst R. Arterial variations in man. J.F. Bergmann, Munchen 1985: 28–35.
31. Loukas M, Stewart D. A case of an accessory testicular artery. Folia Morphol. 2004; 63(3): 355–357, indexed in Pubmed: 15478116.
32. Machnicki A, Grzybiak M. Variations in testicular arteries in fetuses and adults. Folia Morphol. 1997; 56(4): 277–285, indexed in Pubmed: 9635363.
33. Mamatha H, D'Souza AS, Vinodhini P, et al. A cadaveric study about the anomolous origin of testicular arteries arising from the accessory renal arteries. Indian J Surg. 2015; 77(2): 111–116, doi: 10.1007/s12262-012-0737-8, indexed in Pubmed: 26139964.
34. Mamatha Y, Prakash BS, Padmalatha K, et al. Variant course of left gonadal artery: a case report. Int J Ana Var. 2010; 3: 132–133.
35. Mamatha Y, Prakash BS, Padmalatha K. Rare variant origin of right testicular artery: a case report. Asian J Med Scien. 2011; 2(1): 65–67, doi: 10.3126/ajms.v2i1.3860.
36. McMinn RMH. Last's Anatomy, regional and alied. 8th Ed. Churchill Livingstone, Edinburgh 1990: 363.
37. Merklin RJ, Michaels NA. The variant renal and suprarenal blood supply with data on the inferior phrenic, ureteral and gonadal arteries: a statistical analysis based on 185 dissections and review of the literature. J Int Coll Surg. 1958; 29(1): 41–76, indexed in Pubmed: 13502578.
38. Mirapeix RM, Sañudo JR, Ferreira B, et al. A retrocaval right testicular artery passing through a hiatus in a bifid right renal vein. J Anat. 1996; 189 (Pt 3): 689–690, indexed in Pubmed: 8982847.
39. Naito M, Terayama H, Nakamura Y, et al. Left testicular artery arching over the ipsilateral renal vein. Asian J Androl. 2006; 8(1): 107–110, doi: 10.1111/j.1745--7262.2006.00101.x, indexed in Pubmed: 16372128.
40. Naito M, Yi SQ, Terayama H, et al. A left testicular artery arising from a middle mesenteric artery. Clin Anat. 2011; 24(2): 266–267, doi: 10.1002/ca.21090, indexed in Pubmed: 21322051.
41. Nathan H, Tobias PV, Wellsted MD. An unusual case of right and left testicular arteries arching over the left renal vein. Br J Urol. 1976; 48(2): 135–138, indexed in Pubmed: 953421.
42. Nathan H. Aberrant renal artery producing developmental anomaly of kidney associated with unusual course of gonadal (ovarian) vessels. J Urol. 1963; 89: 570–572, indexed in Pubmed: 13937693.

43. Notkovitch H. Testicular artery arching over renal vein: clinical and pathological considerations with special reference to varicocele. Br J Urol. 1955; 27(3): 267–271, indexed in Pubmed: 13269815.
44. Notkovitch H. Variations of the testicular and ovarian arteries in relation to the renal pedicle. Surg Gynecol Obstet. 1956; 103(4): 487–495, indexed in Pubmed: 13360658.
45. Odekunle A, Uche-Nwachi EO. Abnormal testicular vascular patterns amongst three trinidadians: a case report. OnLine J Biol Scien. 2007; 7(1): 18–20, doi: 10.3844/ojbsci.2007.18.20.
46. Onderoğlu S, Yüksel M, Arik Z. Unusual branching and course of the testicular artery. Ann Anat. 1993; 175(6): 541–544, indexed in Pubmed: 8297041.
47. Otulakowski B, Woźniak W. A case of origin of the testicular artery from the renal artery, and course of the testicular artery behind the inferior vena cava. Folia Morphol. 1975; 34(3): 349–351, indexed in Pubmed: 1080739.
48. Ozan H, Gümüşalan Y, Onderoğlu S, et al. High origin of gonadal arteries associated with other variations. Ann Anat. 1995; 177(2): 156–160, indexed in Pubmed: 7741277.
49. Ozdemir MB, Celik HH, Aldur MM. Altered course of the right testicular artery. Clin Anat. 2004; 17(1): 67–69, doi: 10.1002/ca.10119, indexed in Pubmed: 14695592.
50. Pai MM, Vadgaonkar R, Rai R, et al. A cadaveric study of the testicular artery in the South Indian population. Singapore Med J. 2008; 49(7): 551–555, indexed in Pubmed: 18695863.
51. Panyanetinad O. Rare combined variations of renal, testicular and suprarenal arteries. Int J Anatom Variations. 2011; 4: 17–19.
52. Paraskevas GK, Ioannidis O, Raikos A, et al. High origin of a testicular artery: a case report and review of the literature. J Med Case Rep. 2011; 5: 75, doi: 10.1186/1752-1947-5-75, indexed in Pubmed: 21345184.
53. Paraskevas GK, Natsis K, Nitsa Z, et al. Bilateral double testicular arteries: a case report and review of the literature. Potential embryological and surgical considerations. Folia Morphol. 2014; 73(3): 383–388, doi: 10.5603/FM.2014.0057, indexed in Pubmed: 25242354.
54. Pick JW, Anson BJ. The renal vascular pedicle. J Urol. 1940; 44: 411–434.
55. Radojevic S, Stolic E. Note surl' artere spermatique interne. Origine haute en rapport avec le pedicule renal. Bull Assoc Anat (Nancy). 1964; 122: 314–332.
56. Rai R, Ranade AV, Prabhu LV, et al. Variant left testicular artery from the superior polar artery and triple right renal arteries: a case report. Eur J Anat. 2013; 17(4): 262–264.
57. Ravery V, Cussenot O, Desgrandchamps F, et al. Variations in arterial blood supply and the risk of hemorrhage during percutaneous treatment of lesions of the pelviureteral junction obstruction: report of a case of testicular artery arising from an inferior polar renal artery. Surg Radiol Anat. 1993; 15(4): 355–359, indexed in Pubmed: 8128346.
58. Rusu MC. Human bilateral doubled renal and testicular arteries with a left testicular arterial arch around the left renal vein. Rom J Morphol Embryol. 2006; 47(2): 197–200, indexed in Pubmed: 17106531.
59. Salve VM, Ashalatha K, Sawant S, et al. Variant origin of right testicular artery: a rare case. Int J Anatom Variations. 2010; 3: 22–24.
60. Satheesha NB. Abnormal course of left testicular artery in relation to an abnormal left renal vein: a case report. Kathmandu Univ Med J (KUMJ). 2007; 5(1): 108–109, indexed in Pubmed: 18603997.
61. Sheheta R. Arterial supply of the suprarenal glands from the testicular arteries in an arabian cadaver.(case report). Gunma J Med Sci. 1964; 13: 297–300, indexed in Pubmed: 14311739.
62. Shinohara H, Nakatani T, Fukuo Y, et al. Case with a high-positioned origin of the testicular artery. Anat Rec. 1990; 226(2): 264–266, doi: 10.1002/ar.1092260216, indexed in Pubmed: 2301743.
63. Shoja MM, Tubbs RS, Shakeri AB, et al. Origins of the gonadal artery: embryologic implications. Clin Anat. 2007; 20(4): 428–432, doi:10.1002/ca.20438, indexed in Pubmed: 17109441.
64. Singh R, Jaiswal A, Shamal SN, et al. Variation in the origin of the testicular arteries and drainage of the right testicular vein. Int J Morphol. 2011; 29(2): 614–616, doi: 10.4067/s0717-95022011000200052.
65. Soni S, Wadhwa A. Multiple variations in the paired arteries of abdominal aorta: clinical implications. J Clin Diagn Res. 2010; 4: 2622–2625.
66. Sylvia S, Kakarlapudi SV, Vollala VR, et al. Bilateral variant testicular arteries with double renal arteries. Cases J. 2009; 2(1): 114, doi: 10.1186/1757-1626-2-114, indexed in Pubmed: 19187540.
67. Wadhwa A, Sandeep S. A study of gonadal arteries in 30 adult human cadavers. Clinical Medicine Insights: Reproductive Health. 2010; 4: 1–5.
68. Williams PI, Bannister LH, Berry MM, Collins P, Dyson M, Dussek JE, Ferguson M. (eds.), Gray's Anatomy 38th Ed. Churchill Livingstone, New York 1995: 1557.
69. Xue HG, Yang CY, Ishida S, et al. Duplicate testicular veins accompanied by anomalies of the testicular arteries. Ann Anat. 2005; 187(4): 393–398, doi:10.1016/j.aanat.2005.04.007, indexed in Pubmed: 16163852.