VIA MEDICA

ORIGINAL ARTICLE

Folia Morphol.
Vol. 68, No. 4, pp. 271–276

ISSN 0015–5659
www.fm.viamedica.pl

Topographic and morphometric comparison study of the terminal part of human and bovine testicular arteries

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[Received 7 August 2009; Accepted 16 September 2009]

The aim of the study was to compare the terminal parts of testicular artery topography in human and bovine gonads. The study was made on two extremely different types of location of the mediastinum testis. The investigation was carried out on 80 (40 human and 40 bovine) corrosive casts of the testicular arteries.

The differences between the species, including the different course of the testicular artery inside the spermatic cord and in the posterior margin of the gonads, were observed. The division of the testicular artery into terminal branches was located in men on the level of the mediastinum testis, and in bulls close to the inferior end of the gonad. The types of terminal division were similar in both groups. In men, the testicular artery course inside the spermatic cord was more variable than in bulls. The artery was straighter, and in 75% of the cases it did not form the loops which were present in 100% of the bovine specimens. The bovine testicular artery in the posterior margin of the testis was longer and had a more variable course than in men. (Folia Morphol 2009; 68, 4: 271–276)

Key words: testicular artery, human, bull, testis, comparative morphology

INTRODUCTION

Proper blood supply is necessary for the normal functioning of every organ. The testes are particularly sensitive even to transient, minor episodes of ischaemia. Such cases could lead to functional disturbances of the gonad resulting in long-term, difficult to predict disturbances. Therefore, the morphological data concerning supply to arterial vessels and their branches are of great clinical importance. Moreover, mammalian testes are supplied with blood mainly by the testicular artery, but additionally by the deferens duct and cremasteric arteries [19, 22, 23, 26].

The study was made on two groups of testes with extremely different location of the mediastinum testis. The aim of the study was verification of how the difference in *mediastinum testis* topography implies differences in the human and bovine testicular artery course. In humans, the *mediastinum testis* is located peripherally, at the posterior margin of the gonad in its proximal part [23]. In bovines, the *mediastinum testis* is situated in the central part of the gonad [19, 22]. The difference in *mediastinum testis* topography implies large differences in the vascular pattern of the human and bovine masculine gonad. In humans, centrifugal arteries (running from the mediastinal region of the testis) and centripetal arteries (running from surface of the testis) were present [25]. In bulls, the centri-

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petal arteries ran straight to the mediastinal region, where they formed knot-like vascular structures. Those structures were the origin for centrifugal, recurrent branches, running peripherally, which did not reach the surface of the testis [3, 25].

Several studies that have focused on the testicular arteries, both human and bovine, have been contradictory. For example, some authors reported the length of the testicular artery in bulls to be within the range of 140–150 cm [11] while others estimated the same value to range within 340–455 cm [16] or reported it to be 700 cm [19].

Repeatedly, studies of human and bovine testicular arteries were based on small groups of specimens [3, 5, 17, 18, 25, 33]. Therefore, there is still a need for a detailed comparative study of the morphology and topography human and bovine testicular arteries.

The study was designed as a comparative work based on a large number of human (*Homo sapiens*) and bovine (*Bos taurus*) testes, focusing on the topography and morphometry of the testicular arteries.

MATERIAL AND METHODS

Eighty masculine gonads (40 human and 40 bovine) were included in the study. Human testes were taken two days after death. The human donors ranged from 18 to 82 years of age. Bovine testes were taken up to 3 hours after the animal was killed by a butcher. The bulls ranged from 2.5 to 3 years of age. In both groups, none of the organs showed any signs of pathology or disease. The testes were taken together with their coverings. No attempt was made to match the morphological studies to age of the donor or side of the gonad (left or right), and material was analyzed uniformly in every case. The spermatic cord was then isolated and prepared in order to find access to the testicular artery. Corrosive casts of the chosen vessels were obtained by the following process:

— 0.9% NaCl solution was injected into the testicular artery and perfusion was maintain for 10–20 s in order to flush out possible clots;
— saline perfusion was followed by injection of 10 mL of 3% glutaraldehyde solution, in cacodylate buffer (pH 7.4);
— then the vessels were filled with Plastogen G. The resin was stained with red pigment;
— the gonad was then left for 24 hours in warm (20°C) water in order to toughen the resin;
— after toughening, the specimen was placed in 40% KOH solution (50°C) for the next 24 hours to dissolve the organic parts;
— the remnants of the dissolved tissues were removed from the specimen by continuous warm water flush for 24 hours;
— cleaning of the cast continued with a short wash with water and a small amount of standard washing-up liquid and then a final flush with distilled water;
— the cast was later dried out by air flow at room temperature for the appropriate time.

The corrosive casts were examined visually by macroscopic observation using stereoscopic binoculars. The digital photographic documentation was collected for macroscopic and microscopic studies of each specimen. The photographs were saved in jpeg format and later digitally transformed and analyzed using CorelDRAW Graphics Suite 12 software.

The examination included the testicular artery and its branches. After the digital photographic documentation was obtained, the diameter of each artery was measured with a micrometer digital calliper with accuracy of 0.05 mm.

RESULTS

The testicular artery was present in every studied specimen. The artery's course inside the spermatic cord was different in both species. In bovine specimens, in 100% of cases, the artery formed numerous irregular loops which gathered to form a cone-like structure with superiorly pointed apex and the base fixed to the proximal part of the gonad (Figs. 1, 2). The human artery formed similar loops in 17% of cases. The remainder of the studied human arteries showed almost straight (13%) or slightly winding course with no loops (70%). The number of loops was higher in bulls compared to the human arteries with a winding course (Fig. 3). The diameters of the artery casts were in the range 2.5––4.2 mm (in the proximal part of the spermatic cord) or 2.2–3.8 mm (in the distal part of the spermatic cord), and 1.0–1.6 mm (in the proximal part of the spermatic cord) or 0.8–1.4 mm (in the distal part of the spermatic cord) in bulls and men, respectively (Tables 1, 2).

In the proximal part of the bovine spermatic cord, the branch of the deferens duct emerged from the testicular artery. The diameters of the vessel casts were in the range 0.7–2.1 mm (Table 2). This vessel ran from the most proximal loops of the artery to the inferior pole of the gonad, giving off small branches to the trunk and tail of the epididymis (Fig. 1). In humans, no well-developed branch of the deferens duct was observed. However, in the analogical

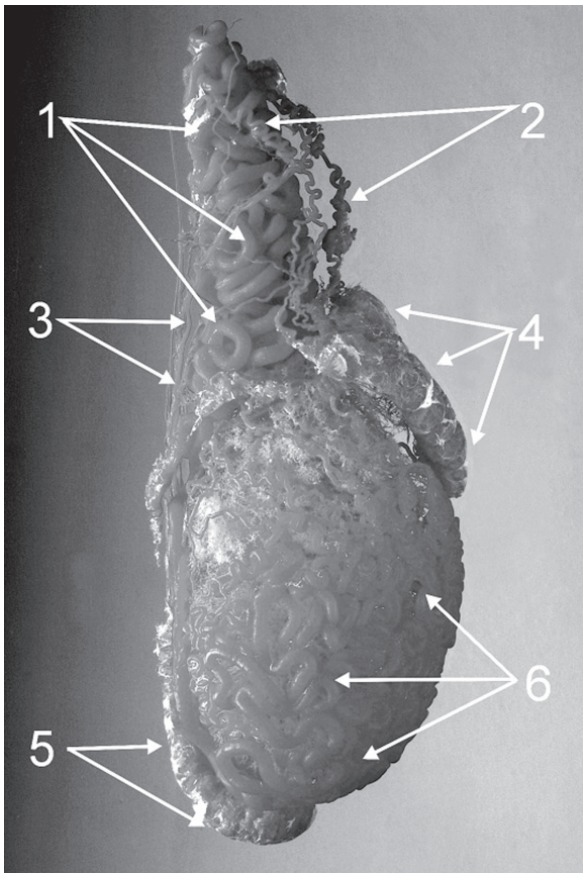

Figure 1. Corrosive cast of bovine arteries: 1 — testicular artery, 2 — arterial branches to the head of epididymis, 3 — deferens duct arterial branch, 4 — arteries of the head of epididymis, 5 — arteries of the tail of epididymis, 6 — extratesticular arteries.

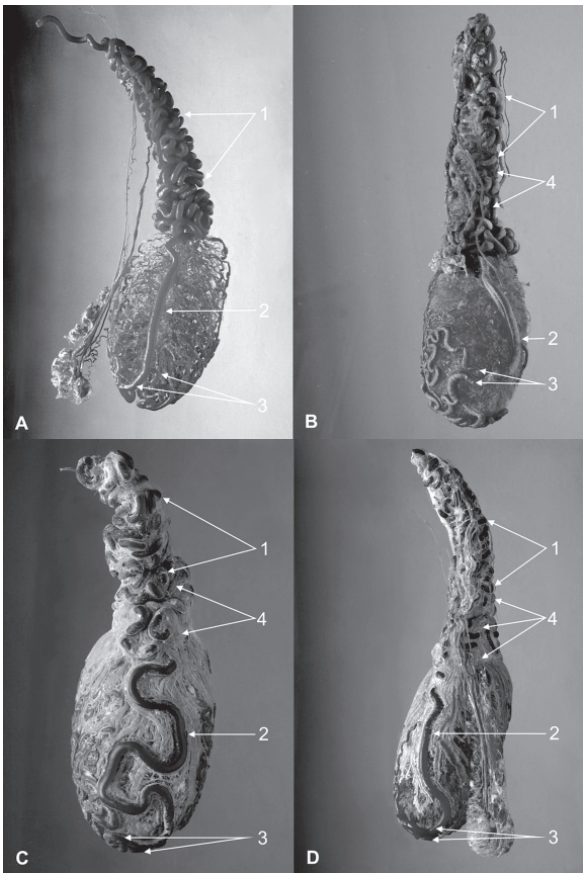

Figure 2. Corrosive cast of bovine testicular blood vessels (morphological type of the testicular artery course in posterior margin of the testes): **A.** Straight, **B.** Arcuate, **C.** Winding (zigzag), **D.** Mixed; 1 — testicular artery in spermatic cord, 2 — testicular artery in posterior margin of the testis, 3 — terminal branches of the testicular artery, 4 — pampiniform plexus veins.

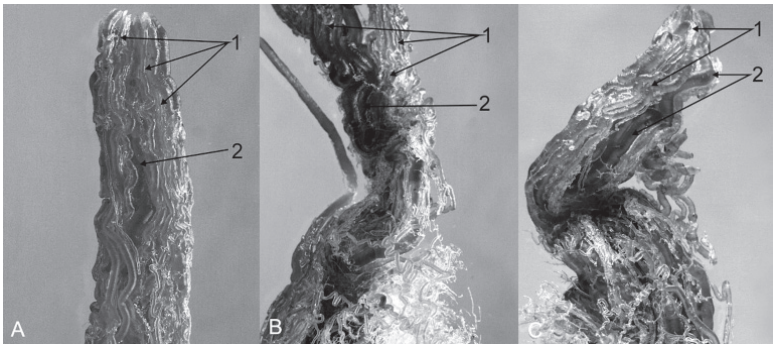

Figure 3. Corrosive cast of human spermatic cord blood vessels (morphological type of the testicular artery course inside spermatic cord): **A.** Almost straight, **B.** Winding with loops, **C.** Slightly winding; no loops; 1 — testicular artery, 2 — pampiniform plexus veins.

location, numerous small arterial vessels connected the trunk of the epididymis and the deferens duct.

The arterial branch running to the head of the epididymis was also present and easily observed in both species. In several cases, two arterial branches of one testicular artery ran to the head of the epididymis (Fig. 1). The diameters of the artery casts were in the range 0.7–1.6 mm and 0.2–0.6 mm in bulls and men, respectively (Tables 1, 2).

Table 1. Diameters of casts of studied human arteries

Artery	No. of specimen	Mean [mm]	Min–Max [mm]	SD [mm]
Testicular artery (in proximal part of spermatic cord)	40	1.25	1.00–1.60	0.15
Testicular artery (in distal part of spermatic cord)	40	1.09	0.80–1.40	0.14
Arterial branch to head of epididymis	40	0.41	0.20–0.60	0.10

Table 2. Diameters of casts of studied bovine arteries

Artery	No. of specimen	Mean [mm]	Min–Max [mm]	SD [mm]
Testicular artery (in proximal part of spermatic cord)	40	2.97	2.40–4.20	0.39
Testicular artery (in distal part of spermatic cord)	40	2.65	2.2–3.80	0.34
Deferens duct branch (of testicular artery)	40	1.02	0.70–2.10	0.23
Arterial branch to head of epididymis	40	1.06	0.70–1.60	0.23

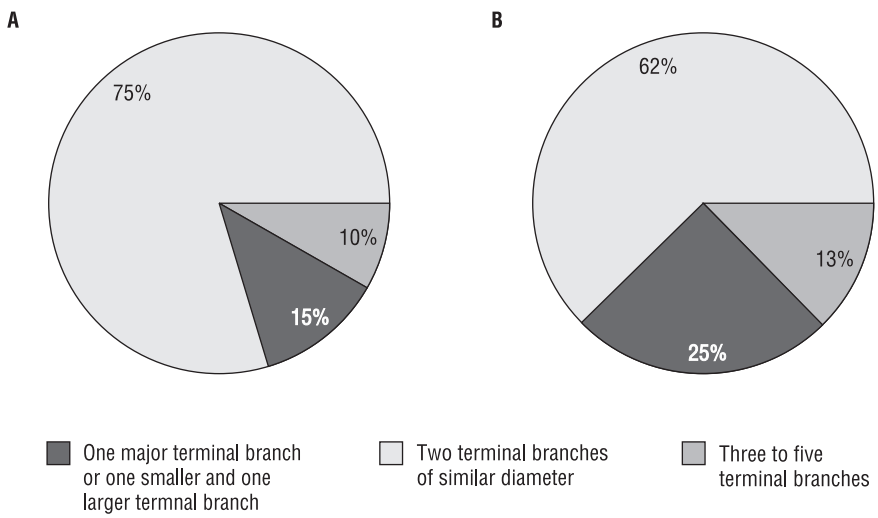

Figure 4. Comparison of terminal division of the testicular artery in men **(A)** and bulls **(B)**.

In both groups, the testicular artery, while going off the spermatic cord, ran along the posterior margin of the testis. In men, this part was straight and very short. In bulls, the testicular artery course in the posterior margin of the testes was more variable than in humans. In 44% of gonads, the testicular artery was of winding (zigzag) course at the posterior margin of the testis. A straight course was present in 23% of cases. In 13% of gonads, a laterally or medially arcuated course was present. The mixed-type course of the artery presented features of all the others. It was found in 20% of cases (Fig. 2).

Terminal division of the testicular artery differed significantly. In humans it was located on the level of *mediastinum testis*. In bulls it was located more inferiorly, close to the inferior end of the testis and the tail of the epididymis. However, in both groups, the testicular artery usually divided into two terminal branches (Fig. 4),

Injection of the arterial vessels with highly penetrative liquid resin resulted, in many cases, in immediate filling of the pampiniform plexus. This phenomenon occurred prior to the filling of the intratesticular capillary network, and the intratesticular and

extratesticular veins. Those observations suggest the presence of direct connections between the arteries and veins in the spermatic cord (Figs. 2, 3).

DISCUSSION

Analysis of the results revealed some differences between the studied species concerning the morphometry and topography of the testicular arteries. Quantitative differences concerned the diameters of the vessel casts. The bovine arteries were generally bigger than human ones.

In our study the testicular artery was present as a single vessel in every human or bovine specimen. We did not observe any doubled testicular arteries. However, variation in the form of doubled testicular arteries was described by Raman and Goldstein [28] in men and by Amselgruber and Sinowatz [1] in bulls.

According to the different localization of the *mediastinum testis,* the human testis is similar to the gonads of the rat, mouse, hamster, stallion, and ape, but the bovine testis is considered as a model of gonads with centrally located *mediastinum*, e.g. the zebu, buffalo, buck, and ram. However, the winding course of the testicular artery was described in all enumerated mammalian testes as well [13–15, 19, 22–24, 27, 32]. In bulls, the numerous vascular loops increase the length of the testicular artery 15––18 times [1]. In our study, only 17% of the human testicular arteries formed similar loops inside the spermatic cord; the majority of the vessels had a straight course. We could exclude atherosclerosis-related changes of the vessel as the reason for pathological winding because many studies have proven the absence of atherosclerosis in human testicular arteries [20, 21, 29, 30]. This suggests that the winding course of the testicular artery was more important for its function in bulls than in men. Thermoregulatory function was the major explanation for the numerous loops of the testicular artery [4, 12, 18]. Dhinjgra [7] expressed the opinion that a decrease in the impact of the arterial pressure pulse was a possible alternative explanation of this morphological feature. Harrison and Weiner [12] described the winding course of the testicular artery in the spermatic cord of the dog, ram, boar, mouse, rat, rabbit, guinea pig, cat, and human. The temperature gradient between abdominal and testicular blood was related to the relative elongation of the testicular artery due to its winding course in the spermatic cord. The gradient was lowest in humans according to the least winding course of the testicular artery in man and higher in species with more arterial loops in the spermatic cord. The interesting findings of Grine and Kramer [10] showed that the length of the testicular artery could be connected with environmental conditions. The testicular artery of humans of Negroid origin from South Africa were longer than those studied in White Caucasians due to the specific, arcuate course in the abdominal cavity. The authors explained their finding as the adaptation to higher external temperature in the native region of the population.

Several hypotheses attempt to explain the topographical relationship between arteries and veins in the spermatic cords, especially the numerous vascular loops in the winding part of the testicular artery, which were observed in our study. The frequently accepted hypotheses are: thermoregulatory function [4, 6, 18] and hormone transportation [2, 8, 9]. These hypotheses explain the winding course of the artery in the spermatic cord by the need of heat or hormone exchange, respectively.

Vascular topography of the major spermatic cord vessels is another significant factor which lowers the pace of blood flow to the gonad. According to previous studies, this topography stabilizes the inner temperature of the testis [18], decreases the amplitude and smoothens the pulsate flow of the arterial blood through the gonad [12], preserves the constant arterial blood pressure inside the testis [31], and makes possible the hormonal flow of testicular hormones from venous to arterial blood [8].

The possible practical conclusion of the study is a recommendation for the best testicular biopsy location for both humans and bulls. The lateral surface of the human gonad and laterally in the middle part of the posterior margin of the bovine gonad seem to be the locations with the least risk of serious bleeding. In the case of bulls, one should be aware of the need to localize the testicular artery pulse before the manoeuvre, which can be done by palpation. According to our study, there are no larger vessels in that area and the vascular density is also relatively low.

CONCLUSIONS

1. The course of the testicular artery inside the spermatic cord was more variable in men than in bulls; in humans, the testicular artery ran usually straighter.
2. The course of the testicular artery on the posterior margin of the gonad was more variable in

bulls than in men; in humans, it was straighter and very short.

3. The testicular artery division into the terminal branches was located on posterior margin of gonad in both groups, but more inferiorly in bulls than in humans; the frequency of the type of division was similar.
4. A well-developed branch of deferens duct was only observed in bovine arterial casts.
5. For biopsy of the testis, the authors recommend the inferior part of the lateral aspect of the gonad in humans, and laterally in the middle part of posterior margin of gonad in bulls, as these areas represent the lowest risk of damage to major vessels.

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