VIA MEDICA

ORIGINAL ARTICLE

Folia Morphol.
Vol. 69, No. 4, pp. 225–231

ISSN 0015–5659
www.fm.viamedica.pl

Arterial supply of human and bovine testes: a topographic and morphometric comparison study

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[Received 16 July 2010; Accepted 11 August 2010]

The aim of the study was to compare the arteries supplying human and bovine masculine gonads. The study was made on two extremely different types of location of the mediastinum testis. The study was made on 100 (50 human and 50 bovine) corrosive casts of the testicular, cremasteric, and deference duct arteries. The differences between the species included different courses of the testicular artery inside the spermatic duct, the relative size of the three arterial diameters, and the morphology of the anastomoses of the arteries.

In human testicular arteries, the course inside the spermatic course was more variable than in that of bulls. The artery was straighter and in 80% of the cases did not form the loops which were present in 100% of the bovine specimens. The bovine testicular artery was significantly wider in relation to the cremasteric and deferens duct arteries than the human one. This finding suggests that collateral blood flow to the testis was less effective in bulls than in men. The human testicular artery directly connected the other two with its terminal branches. The bovine testicular artery connected with the cremasteric and deferens duct arteries indirectly by means of its deferens duct branch. (Folia Morphol 2010; 69, 4: 225–231)

Key words: arterial supply, human and bovine testes, comparison

INTRODUCTION

Proper blood supply is necessary for the normal function of every organ. In the case of the testes, which are relatively sensitive to the influence of external factors, even transient, minor episodes of ischaemia could lead to functional disturbances of the gonad, resulting in long-term, difficult-to-predict disturbances. Therefore, the morphological data concerning the supply of arterial vessels, their branches, and anastomoses are of great clinical importance. Moreover, mammalian testes are supplied with blood not only by the testicular artery, but by the deferens duct and cremasteric arteries as well [22, 24].

Several studies focused on the arteries supplying the testes, both human [6, 7] and bovine [11, 14, 35, 36], have been carried out on relatively small numbers of specimens. The same applies to some comparison studies [15]. As a result, the conclusions of these studies are incomparable and often inconsistent. For example, some authors reported the length of the testicular artery in bulls to be within the 140–150 cm range [8] while others estimated the same value to be within the 340–455 cm range [12] or even report it to be 700 cm [19].

Additionally, our study was made on two groups of testes with extremely different locations of the

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mediastinum testes. The study verified how the difference in mediastinum testis topography implies differences in the human and bovine testicular, deferens duct, and cremasteric artery morphometry and course. In humans, the mediastinum testis is located peripherally, at the posterior margin of the gonad in its proximal part [24]. In bovines, the mediastinum testis is located in the central part of the gonad [22]. The difference in mediastinum testis topography implies large differences in the vascular patterns of the human and bovine masculine gonad. In humans centrifugal arteries (running from mediastinal region of the testis) and centripetal arteries (running from surface of the testis) were present [2]. In bulls, the centripetal arteries run straight to the mediastinal region, where they form knot-like vascular structures. These structures are the origin for centrifugal, recurrent branches, running peripherally, which do not reach the surface of the testis [26].

Previous comparison studies of human and bovine testicular arterial systems in humans and bulls did not sufficiently focus on the arteries which supply the gonads. The studies were based on small groups of specimens [15, 37], describing only the testicular or epididymal arterial network [4, 25–28]. Therefore, there is still the need for a detailed comparative study of the morphology and topography of human and bovine testicular, cremasteric, and deferens duct arteries.

The study was designed as a comparative work based on a large number of human (*Homo sapiens*) and bovine (*Bos primigenius, f. taurus*) testes focusing on the topography and morphometry of the arteries supplying the organ, i.e. the testicular, cremasteric, and deferens duct arteries.

MATERIAL AND METHODS

A hundred specimens of masculine gonads (50 human and 50 bovine) were used in the study. The human testes were taken two days after death. The humans were aged from 18 to 82 years and were free of gonadal disease or pathology in anamnesis. Bovine testes were taken up to three hours after the animal was killed by a butcher. They were aged from 2.5 to 3 years. In both groups none of the organs showed any macroscopic signs of pathology or disease. The testes were taken with the distal part of the spermatic cord and its coverings. No attempt to match the morphological studies to the age of the donor or side of the gonad (left or right) was made and the material was analysed uniformly in every case.

The specimen was prepared in order to gain access to the testicular artery, the cremasteric artery, and the deferens duct artery. Subsequently, the identified arteries were injected with 0.9% NaCl solution and perfusion was maintained 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). After that, two of the arteries were ligated by surgical suture. The third vessel was filled with plastogen G synthetic resin, which gradually entered the lumen of the other arteries as well.

Specimens filled with the resin were left for 24 hours in warm (20°C) 0.9% saline solution. After hardening, the specimens were placed into 40% KOH solution (50°C) for the following 24 hours to dissolve the majority of the organic parts. The remnants of dissolved tissues were removed from the specimen by continuous flush with warm water for the next 24 hours. The cleaning process was continued by short water wash with a small amount of standard washing-up liquid and a final flush of distilled water.

The vascular casts were later dried out by air flow at room temperature for the appropriate time. Next, the casts were examined visually by macroscopic observation and by stereoscopic binocular. The examination included the testicular artery and its branches, the cremasteric and deferens duct arteries, and the relationships and anastomoses among these structures. After digital photographic documentation was obtained, the diameter of every artery was measured with a micrometer digital caliper with an accuracy of 0.05 mm. The measurements were made within the spermatic cord, proximal to the convoluted part of the testicular artery, and at the same level for every vessel.

RESULTS

Testicular arteries

In both species the testicular artery was present in every studied specimen. The diameter of the artery's cast fitted in the ranges 2.5–4.2 mm and 1.0––1.5 mm in bulls and men, respectively (Tables 1, 2). The course of the arteries inside the spermatic cord was different in both species. The bovine artery formed numerous vascular loops in 100% of cases, which did not form any regular pattern (Figs. 1, 2). The human artery formed similar loops in 20% of cases. The other of the studied human arteries showed almost straight (10%) or slightly winding course with no loops (70%). The number of the loops

Table 1. Diameters of the casts of the studied human arteries

Artery	No. of specimens	Mean [mm]	Min–max [mm]	Std. dev. [mm]
The testicular artery	50	1.24	1.00–1.50	0.14
The deferens duct artery	50	0.77	0.60–1.10	0.14
The cremasteric artery	50	0.43	0.30–0.70	0.13

Table 2. Diameters of the casts of the studied bovine arteries

Artery	No. of specimens	Mean [mm]	Min–max [mm]	Std. dev. [mm]
The testicular artery	50	2.94	2.50–4.20	0.43
The deferens duct artery	50	0.86	0.60–2.00	0.27
The cremasteric artery	50	0.57	0.40–0.90	0.14
The deferens duct branch (of the testicular artery)	50	1.04	0.70–2.10	0.26

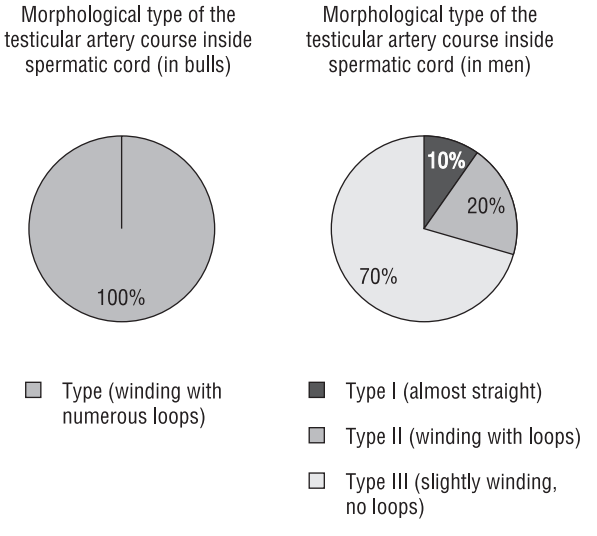

Figure 1. Comparison of morphology of the testicular artery course inside the spermatic cord in bulls and men.

was higher in bulls compared to the human arteries of winding course (Figs. 1, 3).

In proximal part of the bovine spermatic cord the testicular artery gave off a branch of the deferens duct. The diameter of the vessel's cast was in the 0.7–2.1 mm range. 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 (Figs. 2, 4). In humans, no

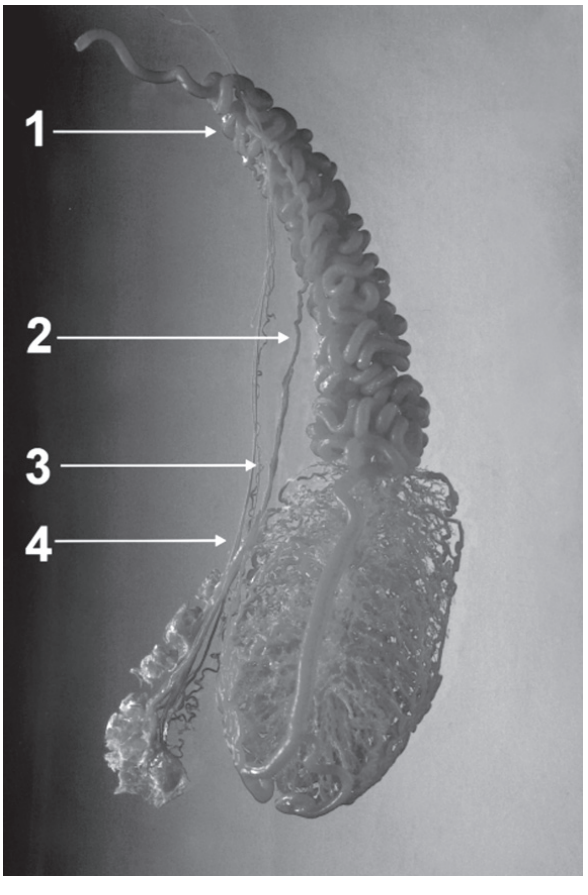

Figure 2. Corrosive cast of bull testis arterial vessels; 1 — testicular artery; 2 — the deferens duct branch of the testicular artery; 3 — the cremasteric artery; 4 — the deferens duct artery.

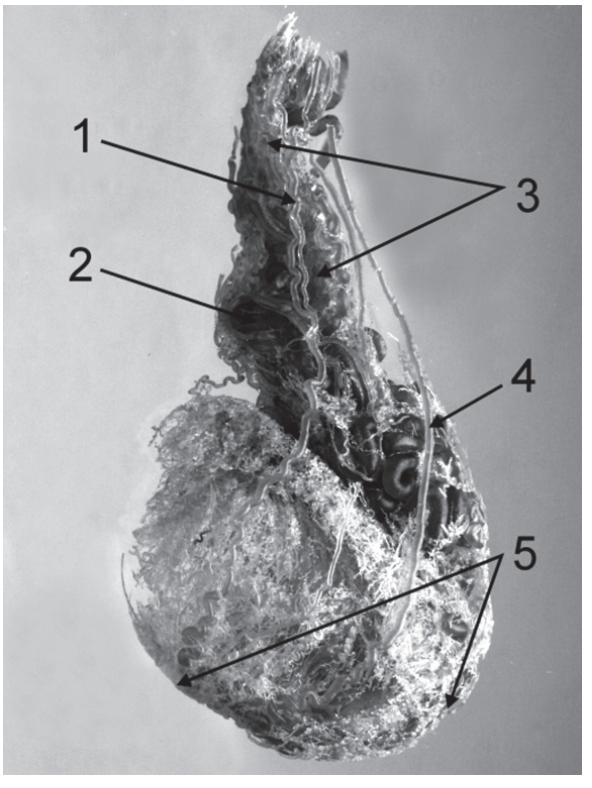

Figure 3. Corrosive cast of human testis arteries: 1 — the cremasteric artery, 2, 3 — the testicular artery, 4 — the deferens duct artery, 5 — the extratesticular arteries.

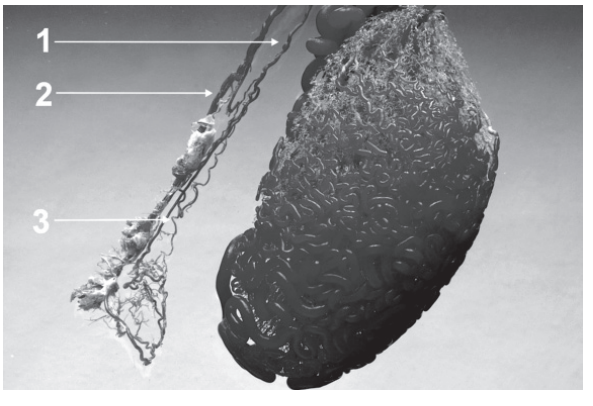

Figure 4. Corrosive cast of bull testis arteries; 1 — the deferens duct artery; 2 — the deferens duct branch of the testicular artery; 3 — the cremasteric artery.

well-developed branch of the deferens duct was observed. However, in analogical location, numerous small arterial vessels connected the trunk of the epididymis and the deferens duct.

Deferens duct arteries

In both species the deferens duct artery was present in every studied specimen. The diameter of the artery's cast fitted in the ranges 0.6–2.0 mm and 0.6–1.1 mm in bulls and men, respectively (Tables 1, 2). In 100% of cases the course of the artery was almost straight. The artery reached the testis close to the superior pole of the gonad (Figs. 2, 3). In that area the deferens duct artery gave off singular, tiny branches to the trunk of the epididymis. The number of these vessels was higher in bulls than in humans. The artery ran inferiorly to the tail of the epididymis. The bovine deferens duct artery fused with the cremasteric artery and the branch of the deferens duct coming out of the testicular artery (Fig. 4). The human deferens duct artery fused with the testicular and cremasteric arteries (Fig. 5).

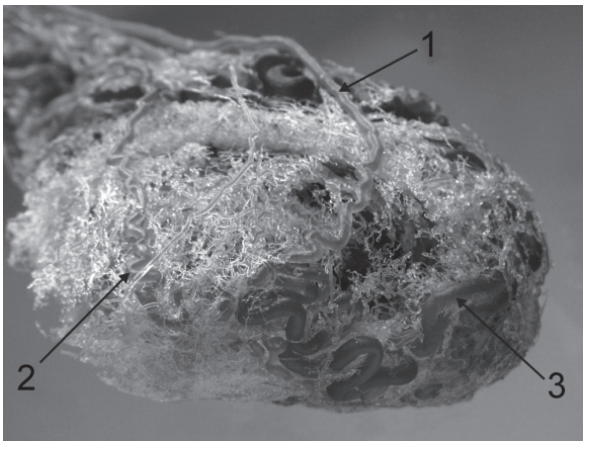

Figure 5. Corrosive cast of the human testis arteries; 1 — the deferens duct artery; 2 — the cremasteric artery; 3 — the testicular artery.

Cremasteric arteries

In both species the cremasteric artery was present in every studied specimen. The diameter of the artery's cast fitted in the ranges 0.4–0.9 mm and 0.3–0.7 mm in bulls and males, respectively (Tables 1, 2). In 100% of cases the course of the artery was winding, both inside the spermatic cord and close to the testis (Figs. 2–4). The artery gave off singular, winding branches along its entire length. In the area of the tail of the epididymis the cremasteric artery was present as a single vessel. Alternatively, some smaller arterial branches replaced the terminal part of the artery. This topography was observed in both species (Fig. 5, 6).

Arterio-arterial anastomoses

The resin injected into the testicular artery also filled the deferens duct artery and cremasteric artery by means of backflow. This phenomenon was observed in every specimen of both species due to

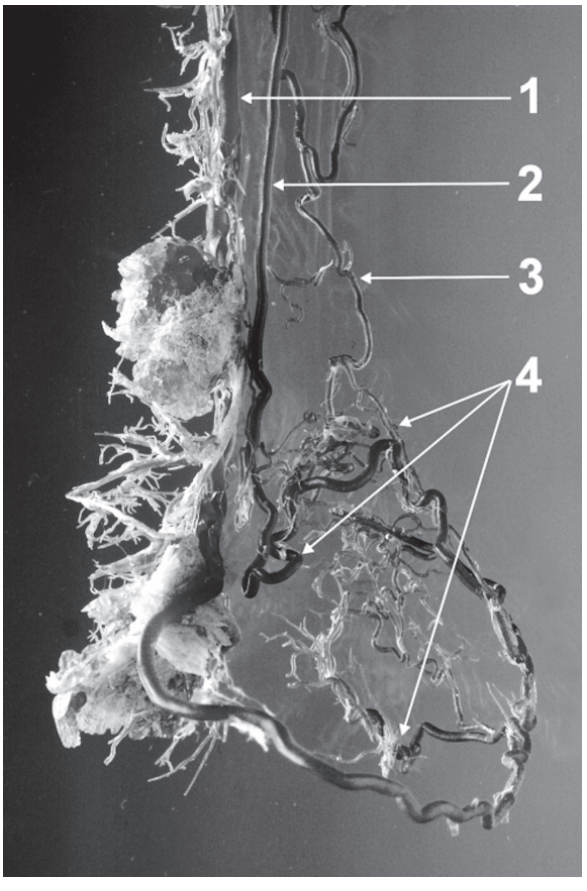

Figure 6. Corrosive cast of bull testis arteries; 1 — the deferens duct branch of the testicular artery; 2 — the deferens duct artery; 3 — the cremasteric artery; 4 — arterio-arterial anastomoses.

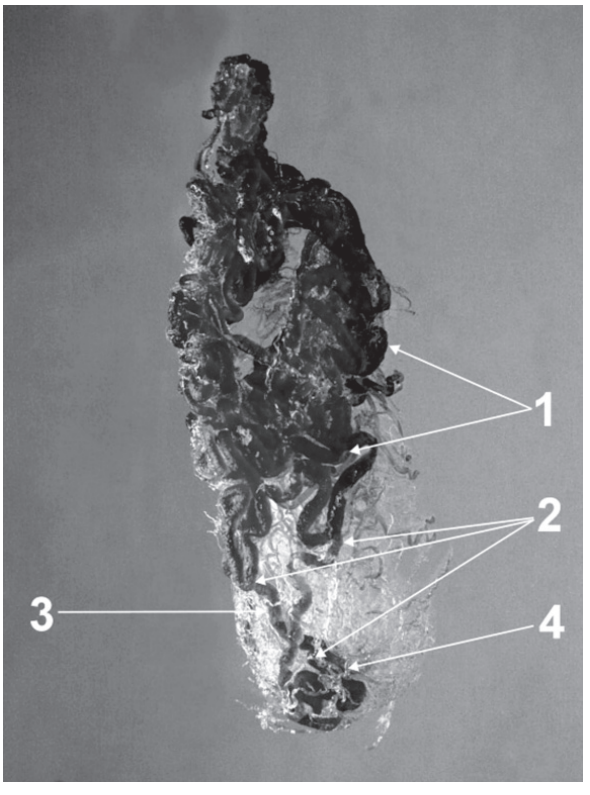

Figure 7. Corrosive cast of the human testis arteries; 1 — the testicular artery; 2 — arterio-arterial anastomoses; 3 — the cremasteric artery; 4 — the deferens duct artery.

the presence of arterio-arterial anastomoses among all three vessels. The analysis of corrosive casts confirmed this observation. The arterio-arterial anastomoses in 100% of bovine specimens were located close to the tail of the epididymis. In humans 60% of cases showed the same location. However, in 40% of the human specimens the anastomoses were located between the upper pole of the testis and the trunk of the epididymis.

In bulls, the anastomosing connection between the deferens duct artery and the deferens duct branch of the testicular artery was well developed in every case and had a horseshoe or U-like shape (Fig. 6). The cremasteric artery or its terminal branches fused to this connection.

In humans, the deferens duct artery fused directly with the testicular artery and the cremasteric artery. In some cases the terminal branches of the cremasteric artery joined the connection. The connecting parts of the arteries formed a U-like or superiorly open eight-like vascular structure (Fig. 7)

DISCUSSION

Analysis of the results revealed differences between the studied species concerning morphometry and topography of the arteries supplying the examined gonads.

There were quantitative differences in the diameters of the casts of the vessels. The bovine arteries were generally larger than the human ones. However, such a relationship was much more significant for testicular arteries than for the cremasteric or deferens duct arteries. The mean diameter of the testicular artery casts in bulls was 137% larger than that of humans. The mean diameter of the casts of the cremasteric artery was only 33% larger, and that of the deferens duct artery only 12% higher in bulls than in men. The mean diameter of human testicular artery casts in the studied material approximately equalled the sum of the diameters of the casts of the other two arteries (1.24 mm *vs* 0.77 mm + 0.43 mm = 1.20 mm), which supports previous findings [38]. However, the bovine testicular artery was more than twice as thick as the sum of the other two artery casts supplying the testis (2.94 mm *vs* 0.86 mm + + 0.57 mm = 1.43 mm). It can be concluded that

the blood supply of the testis by the deferens duct and cremasteric arteries is less effective in bulls than in men. This fact could result in insufficient collateral blood supply in cases of acute obliteration of the testicular artery in bulls. Nevertheless, some scientists have suggested that collateral blood flow through the cremasteric and deferens duct arteries is also ineffective in men in cases of testicular artery ligation [30].

In our study the testicular artery was present as a single vessel in every case of both human and bovine specimens. We did not observe any double testicular arteries. However, variations in the form of doubled testicular arteries have been described in men [30] and in bulls [1].

There were qualitative differences in the course of the testicular arteries inside the spermatic cord and in the morphology of the arterio-arterial anastomoses among terminal branches of the testicular, cremasteric, and deferens duct arteries. The winding course of the testicular artery was described not only in men and bulls but also in other mammalian species [9, 10, 29, 34]. In bulls, the numerous vascular loops increased the length of the testicular artery by 15–18 times [1]. In our study only 20% of the human testicular arteries formed similar loops inside the spermatic duct; the majority of the vessels had a straight course. We could exclude atherosclerosis-related changes of the vessels as the reason for this pathological winding as many studies have proven the absence of atherosclerosis in human testicular arteries [20, 21, 32, 33]. It suggested that the winding course of the testicular artery is not as important to its function in men as it is in bulls. Thermoregulatory function is the most popular explanation for the numerous loops in the testicular artery [3, 9, 15]. Some scientists have expressed the opinion that decreasing the impact of the arterial pressure pulse is a possible alternative explanation for this morphological feature [5]. In species with more vascular loops of the testicular artery the difference between blood temperatures measured inside the abdominal cavity and in testis was higher (the study included testicular arteries of the dog, ram, boar, mouse, rat, rabbit, guinea pig, cat, and human) [9]. From such a perspective, the bovine testicular artery should be more effective in cooling the arterial blood than is the human testicular artery.

The arterio-arterial anastomoses were made directly by the testicular artery in men, and indirectly by the branches of the testicular artery in bulls. Our findings in human testes were consistent with previous studies [13, 23, 30, 38]. Our findings in bovine testes showed a morphological similarity to previously described anastomoses among the testicular, cremasteric, and deferens duct arteries in the ram [16], boar [17], and stallion [18]. The alternative morphology with anastomosis, made mainly by the testicular artery and the deferens duct artery, was described in the rat [31]. In humans the direct fusion of all three arteries supplying the testis is another morphological finding supporting the hypothesis of effective collateral blood flow, which involves both the cremasteric and deferens duct arteries. The functional importance of the arterio-arterial anastomoses of the arteries supplying the testis is also supported by a study which described a lack or hypotrophy of such anastomoses in undescended human testes [38].

CONCLUSIONS

1. The course of the testicular artery is more variable in men than in bulls; the human testicular artery inside the spermatic cord usually runs straighter.
2. The course of the cremasteric artery and the deferens duct artery is similar in both species.
3. The anastomosis among the testicular, cremasteric, and deference duct arteries is direct in men (through the terminal branches of the testicular artery) and indirect in bulls (through the deferens duct branch of the testicular artery).
4. The collateral arterial blood flow by means of the cremasteric and deferens duct arteries is more efficient in men than in bulls, which could lead to negative clinical consequences of testicular artery obliteration more in bulls than in men.

REFERENCES

1. Amselgruber W, Sinowatz F (1987) Zur Beziehung zwischen der Arteria testicularis und den Venen des Plexus pampiniformis beim Bullen. Anat Histol Embryol, 16: 363–370.
2. Bolanowski W, Jędrzejewski KS, Oszukowski P, Polguj M (2008) Topografia naczyń krwionośnych jądra buhaja. Med Wet, 64: 1244–1247.
3. Brito L, Silva A, Barbosa T, Kastelic J (2004) Testicular thermoregulation in Bos indicus, crossbred and Bos taurus bulls: relationship with scrotal, testicular vascular cone and testicular morphology, and effects on semen quality and sperm production. Theriogenology, 61: 511–552.
4. Cendrowska I, Jędrzejewski KS, Okraszewska E (1996) Angioarchitecture of the epididymis in men, bull and ram. Folia Morphol, 55: 227–228.

5. Dhinjgra L (1979) Angioarchitecture of the Buffalo Testis. Anat Anz, 146: 60–68.
6. Ergun S, Stingl J, Holstein A (1994) Segmental angioarchitecture of the testicular lobule in man. Andrologia, 26: 143–150.
7. Ergun S, Stingl J, Holstein A (1994) Microvasculature of human testis in correlation to Leydig cells and seminiferous tubules. Andrologia, 26: 255–262.
8. Gutzschebauch A (1936) Der Hoden der Haussagetiere und sein Hulen in biologisher und artdiagnostischer Hinsticht. Z Anat Ew Gesch, 105: 433–458.
9. Harrison R, Weiner J (1949) Vascular patterns of the mammalian testis and their functional significance. J Exp Biol, 26: 304–316.
10. Harrison R (1949) The comparative anatomy of the blood-supply of the mammalian testis. Proc Zool Soc Lond, 119: 325–344.
11. Hess H, Leiser R, Kohler T, Wrobel K (1984) Vascular morphology of the bovine spermatic cord and testis. Light- and scanning electron-microscopic studies on the testicular artery and pampiniform plexus. Cell Tiss Res, 237: 31–38.
12. Hofman R (1960) Die Gefarchitektur des Bullenhodens, zugleinch ein Versuch ihrer funktionellen Deutung. Zentralbl. Veterinarmed, 7: 59–93.
13. Horstman WG, Middleton WS, Melson GL, Siegel BA (1991) Color Doppler US of the scrotum. RadioGraphics, 11: 941–957.
14. Hundeiker M (1966) Die Kapillararchitectur im Stierhoden. Angiology, 3: 343–348.
15. Hundeiker M (1972) Vasculare Regulationseinrichtungen am Hoden. Arch Derm Forsch, 245: 229–244.
16. Jantosovicova J (1977) Topografico-anatomic data on the arteria testicularis, arteria ductus deferentis and arteria cremasterica in ram. Gegenbaurs Morphol Jahrb, 123: 914–923.
17. Jantosovicova J, Jantosovic J (1980) Topografico-anatomic data on the arteria testicularis, arteria ductus deferentis and arteria cremasterica in the boar. Gegenbaurs Morphol Jahrb, 126: 756–765.
18. Jantosovicova J, Jantosovic J (1983) Topografico-anatomic data on the testicular artery, ductus deferens artery and cremaster artery in the stallion. Gegenbaurs Morphol Jahrb, 129: 467–482.
19. König HE, Liebich HG (2007) Veterinary anatomy of domestic mammals. Schattauer Verlag, Stuttgart.
20. Kormano M, Suoranta H (1971) An angiographic study of the arterial pattern of the human testis. Anat Anz, 128: 69–76.
21. Kormano M, Suoranta H (1971) Microvascular Organization of the adult human testis. Anat Rec, 170: 31–40.
22. Krysiak K, Świeżyński K (2008) Anatomia zwierząt. Narządy wewnętrzne i układ krążenia. PWN, Warszawa.
23. Middleton WD, Thore DA, Melson GL (1989) Color Doppler ultrasound of the normal testis. Am J Radiol, 152: 293–297.
24. Moore K, Dalley A (2006) Clinically oriented anatomy. Lippincott Wiliams & Wilkins, Philadelphia.
25. Mostafa T, Labib I, El-Khayat Y, El-Rahman El-Shahat A, Gadallah A (2008) Human testicular arterial supply: gross anatomy, corrosion cast, and radiologic study. Fertil Steril, 90: 2226–2230.
26. Polguj M, Jędrzejewski KS, Bolanowski W (2008) Comparison of blood vessels complex of human and bovine masculine gonad. Folia Morphol, 67: 87–97.
27. Polguj M, Jędrzejewski KS, Oszukowski P, Bolanowski W (2009) Topography of the terminal part of the bovine testicular artery. Med Wet, 65: 61–64.
28. Polguj M, Jędrzejewski KS, Dyl Ł, Topol M (2009) Topographic and morphometric comparison study of the terminal part of human and bovine testicular arteries. Folia Morphol, 68: 271–276.
29. Pozor M, Kolonko D (2001) The testicular artery of stallions in clinical and morphological studies. Med Wet, 57: 822–826.
30. Raman JD, Goldstein M (2004) Intraoperative characterization of arterial vasculature in spermatic cord. Urology, 64: 561-564.
31. Romero-Maroto J, Verdu-Tartajo F, Garcia-Gonzalez R, Gonzalez-Gancedo P, Cacicedo L (1986) The functional value of collateral testicular vascularization. Br J Urol, 58: 553–556.
32. Sasano N, Ichijo S (1969) Vascular patterns of the human testis with special reference to its senile changes. Tohoku J Exp Med, 99: 269–275.
33. Takyama H, Tomoyoshi T (1984) Microvascular architecture of rat and human testis. Invest Urol, 132: 341––344.
34. Weerasooriya T, Yamamoto T (1985) Three- dimensional organization of the vasculature of the rat spermatic cord and testis. Scanning electron-microscopic study of vascular corrosion casts. Cell Tissue Res, 241: 317––323.
35. Wrobel K, Sinowatz F, Mademann R (1981) Intratubular topography in the bovine testis. Cell Tiss Res, 217: 289–310.
36. Wrobel K, Sinowatz F, Mademm R (1982) The fine structure of the terminal segment of the bovine seminiferous tubule. Cell Tiss Res, 225: 29–44.
37. Wyrost P, Radek J, Radek T (1990) Morfologia i rozwój tętnicy jądrowej (*A. testicularis*) bydła w okresie płodowym i neonatalnym. Pol Arch Wet, 30: 41–54.
38. Yalcin B, Komesli GH, Ozgok Y, Ozan H (2005) Vascular anatomy of normal and undescended testes: surgical assessment of anastomotic channels between testicular and deferential arteries. Urology, 66: 854–857.