Arteries of the scrotum: a microvascular study and its application to urethral reconstruction with scrotal flaps

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OBJECTIVE
To study scrotal microvascularization and apply the findings to the design of reliable skin flaps for reconstructive surgery of complex urethral or panurethral stenoses.

MATERIALS AND METHODS
In 15 cryopreserved male cadavers, scrotal skin vascularization was explored using macro- and microdissections, and the scrotal sac made transparent using the Spalteholtz method. A meticulous descriptive analysis of the arterial network was conducted out in all cases to evaluate the number, distribution and anastomosis of the cutaneous arteries of the scrotum.

RESULTS
Scrotal skin is irrigated by two main vascular systems, through the inferior external pudendal arteries and the perineal arteries, which branch into multiple scrotal arteries. These arteries are distributed in three cutaneous territories, two lateral and one central, which are widely inter-anastomosed. Each lateral territory receives an inferior external pudendal artery which accesses at the midpoint of the scrotal root and fans out to cover the entire corresponding hemiscrotum. The central cutaneous territory is vascularized through the branches of two main scrotal arteries which are a continuation of the perineal arteries and which access via the posterior face, running deeply on both sides of the septum.

CONCLUSIONS
The special anatomical distribution of scrotal branches stemming from perineal arteries enables the construction of adequate reliable longitudinal median island scrotal flaps for the reconstructive surgery of panurethral stenosis, as profuse axial vascularization is ensured.

KEYWORDS
arteries, blood supply, scrotum, surgical flaps, urethral stricture, urethroplasty

INTRODUCTION
In any reconstructive surgery, axial flaps are more reliable than grafts, as the blood supply is always guaranteed when vascular continuity is well preserved [1]. Many penile and scrotal skin flaps to reconstruct complex urethral stenosis have been described, but most were not supported by previous microvascular studies, which could explain their variable outcomes.

Scrotal skin is well vascularized due to the confluence of two main arterial systems, the external iliac and the internal iliac, as described in classic anatomical texts and atlases [2–7], and specialized books and texts on microvascular anatomy [8–10]; however, recent and well-detailed descriptions are scarce or unavailable. Our aim was to study the arterial microvascular distribution of the scrotum and apply the findings to improving the results of complex urethral surgery.

MATERIALS AND METHODS
Fifteen cadavers of men aged 53–92 years, cryopreserved and with arterial black latex injected through the internal and external iliac arteries, were studied using a combination of different techniques. The bilateral inguinal regions and the perineoscrotal area were dissected to identify the origin of the main arterial vessels that vascularize the scrotum.

Microdissections of scrotal cutaneous arteries using magnifying lenses (×2.5) were carried out from inside and outside the scrotal wall, with each layer identified and raised successively.

RESULTS
Scrotal blood supply from the external iliac system: Two external pudendal arteries (superior and inferior) were found stemming from the femoral artery at a mean distance of 5 cm below the inguinal ligament in 95% of cases. One arterial trunk dividing into these
two branches was found in 65% of cases (Fig. 1).

Scrotal vascularization was exclusively through branches of the inferior external pudendal artery in 89.5% of cases. Both external pudendal arteries or a single external pudendal artery were responsible for scrotal blood supply in the remaining cases. These arteries enter the scrotal sac laterally at the mid-point of its base or root, then bifurcate and are distributed throughout the entirety of the skin of each hemi-scrotum (Fig. 2).

**Scrotal blood supply from the internal iliac system:** A perineal artery (superficial perineal artery) branching from the internal pudendal artery was located bilaterally in the perineal area in all cases. All these vessels gain access in the perineal region, perforating the perineal membrane in the triangular space formed in front of the superficial transverse muscle of the perineum, and between the ischiocavernosus and bulbospongiosus muscles. This emergence point was found at a mean distance of 1.9 cm lateral to the median perineal raphe, along the line joining the two ischial tuberosities passing through the anterior margin of the anal orifice. In depth, the arterial emergence point was at a mean of 4.5 cm from the cutaneous surface. Both superficial perineal arteries traced an anterosuperior route towards the rear face of the scrotum (lithotomy position), being located deep in the space between the ischiocavernosus and bulbospongiosus muscles (Fig. 3). At the root of the scrotum, each perineal artery splits into fine branches that are distributed in the skin of this area, and a main branch, of larger diameter, which continues a deep course towards the interior of the scrotal sac (Fig. 4). This main branch runs ventrally along the urethral corpus spongiosum at each side of the scrotal septum insertion, following an anterior direction, and branching out into several arteries that descend obliquely over the septum (Fig. 5). When these septal arteries reach the superficial end of the septum, they turn towards the skin of each hemiscrotum at the median line where they are distributed (Figs 6,7).

In addition, in 70% of cases the skin of the superolateral region of the scrotum had supplementary irrigation from a lateral artery originating in the medial femoral circumflex artery (83% of cases) or in the obturator artery (17%). There were
anastomoses between the arteries of each scrotal vascular region.

**DISCUSSION**

The use of scrotal and penile skin flaps in reconstructive surgery of bulbar urethral stenosis has declined since the advent of free buccal mucosa grafts. However, there are cases of complex bulbar stenosis (very extensive, multi-operated and with chronic urinary infection) or panurethral disease in which reconstruction with a scrotal skin flap is an option to be considered before a definitive perineal urethrostomy.

Different urethroplasty techniques with scrotal flaps have been described [12–16]; however, the design of most was based on the understanding of classical anatomy and not on microvascular studies, which might support the existence of axial-type vascularization and thus assure their suitability and reliability. As classically described, scrotal skin has a dual blood supply through branches from the external and internal iliac systems, respectively, distributed in anterior and posterior faces of the scrotum [2,3,8]. However, our results show the existence of three cutaneous territories; two lateral and one central (Fig. 8). Classically and in recent texts, perineal arteries were considered to only irrigate the posterior face of the scrotum [9,10,16]; however, the present study showed that all the skin from the scrotal midline to its insertion into the mid penile raphe receives its vascularization via the perineal arteries and their branches.

Understanding of the exact anatomical location of these vessels is necessary to ensure their inclusion in the skin flap and avoid surgical manoeuvres that could harm them. In this respect, several surgical landmarks should be considered throughout their route.

Regarding the exit point of these arteries in the perineal region, incisions at the base of a flap of the scrotal midline must move away laterally from ischiocavernous to avoid injury. Fortunately, the characteristic deep exit site of both perineal arteries prevents them from being injured in their main trunk when a superficial skin incision is made.

To ensure inclusion in the scrotal flap of the main trunk of both perineal arteries...
situated between the ischiocavernosus and bulbospongiosus muscles, it will be necessary to raise them within the plane of the fascia of these muscles or, even more safely, subfascially, while taking special care in the intermuscular space, as indicated in a perineally based scrotal flap urethroplasty [15].

The particular ventral route of both perineal arteries with respect to the corpus spongiosum of the urethra and exit of its branches towards the scrotal septum, advocate the routine inclusion of the septum in scrotal flap construction, and thus preserve this important vascularization. However, anatomical findings have shown that perineally based flaps of the scrotal midline can be adequately designed in length and width without their vascularization being compromised.

As the median line of scrotal skin, on the posterior and anterior faces, depends on vascularization through perineal arteries, posterior scrotal midline flaps are not limited in length and could be raised, with no risk, up to the anterior face of the scrotum. Thus, this permits long cutaneous island flaps to be obtained that can be moved and sutured free from tension.

Confirmation of the existence of anastomosis between the arteries of the two lateral arterial territories with a central territory, forming a true scrotal network as described by several authors [8–10], permits the design of flaps of the scrotal central line with variable amplitude, without endangering the vascularization of their lateral zones.

Finally, direct connections between the arteries of the right- and left-hand sides at the level of the scrotal skin of the median line could ensure vascularization of the whole flap in the event of lesions to the vascular supply of one of the sides of the septum.
Some authors have described flaps for complex urethral reconstruction based on the distribution of perineal artery branches in other territories [14,16,17] or exclusively on the septal blood supply [13]. Without doubt, according to our results, a raised flap in the posterolateral scrotal skin is vascularized by fine branches of the ipsilateral perineal artery that are distributed in the area. Such a flap must be considered as a ‘random’ flap, given that it will remain nourished through arterial interconnections of the dartos, but will not count on an axial vessel making its vascularization totally predictable. Septum pedicled scrotal skin flaps are randomly vascularized by fine septal arteries that can be easily damaged when surgical incisions are deepened in the scrotal septum to obtain an adequate mobilization of the flap.

In no case did we find a distribution of perineal artery branches in the superficial fascia of the internal thigh laterally contiguous to the inguinal fold, as described in diagrams of a urethroplasty technique for complex cases [16,17].

In conclusion, the scrotum receives a good arterial supply from two main arterial systems that determine the existence of three cutaneous territories; two lateral, each dependent on an inferior external pudendal artery, and one central, dependent on perineal arteries, which includes the anterior and posterior faces and the septum. The three territories are widely interconnected by a veritable scrotal arterial network.

Microvascular anatomical study of the distribution of scrotal branches of the perineal artery permits the design of skin flaps of the central scrotal territory, sufficiently long (from the scrotal root to the base of the penis) and variable width, thereby guaranteeing axial vascularization. The surgical execution of these flaps must respect certain important surgical landmarks and preferentially include the septum.

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CONFLICT OF INTEREST

None.

REFERENCES


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