ISSN 1008-682X
Shanghai Institute of Materia Medica
Chinese Academy of Sciences
http://www.AsiaAndro.com

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Penile venous anatomy: application to surgery for erectile disturbance

Geng-Long HSU, Cheng-Hsing HSIEH, Hsien-Sheng WEN,
Tzu-Jan KANG, Han-Sun CHIANG[1]

Department of Urology, Taiwan Adventist Hospital, Po-Jen General Hospital, Taipei
[1]Taipei Medical University Hospital, Taipei

Keywords: deep dorsal vein; cavernosal vein; para-arterial vein; tunica albuginea

Abstract **Aim:** The structure of the human penile venous system has been well studied, but disappointing outcomes of penile venous surgery in certain patients have called into question on the anatomy. We planned to extend the anatomic knowledge with the ultimate goal of improving operative success. **Methods:** Thirty-five patients, who had undergone penile venous surgery, complained of poor erection developed gradually 6 months to 7 years postoperatively. Cavernosography was performed again during their return visit. Seven new patients underwent spongiosography followed by immediate cavernosography. Eleven male cadavers were carefully dissected. The anatomical findings were applied to venous surgery in 155 patients, who were then followed with the International Index of Erectile Function Questionnaire-5 (IIEF-5). **Results:** Imaging observation demonstrated that the deep dorsal vein served as a common vessel of the corpora cavernosa and corpus spongiosum. A prominent cavernosal vein was found coursing along each corpus cavernosum distally to the glans, in contrast to its reported description as a short segment at the penile hilum. All cadavers had two sets of para-arterial veins sandwiching the dorsal artery. In 148 men available for follow-up, their mean IIEF-5 score was 9.3 preoperative and increased to 22.7 after the operation. The 88.5% (131/148) of the patients believed that venous stripping was a worthy treatment modality. Five cases required sildenafil to maintain their potentia, which was not working preoperatively. **Conclusions:** The failure of penile venous surgery has traditionally been ascribed to penile vein regeneration. However, our finding of a long and independent cavernosal vein and an independent set of para-arterial veins may be the principal cause in patients experiencing poor postoperative results. *(Asian J Androl 2002 Mar; 4 : 61-66)*

1 Introduction

The anatomy of the human penile venous system has been well studied [1-5]. Over the past 15 years, we performed penile venous stripping surgery in 1845 patients in accordance with the published descriptions of the deep dorsal vein and the short cavernous vein. Unfortunately, some patients experienced a poor postoperative result, which was ascribed to residual veins demonstrable on follow-up cavernosography. In these films, each corpus cavernosum was seen to have its own cavernosal vein running almost the entire length of the corpus. This surprising finding in patients with erectile dysfunction confirmed by serial cavernosograms prompted us to fur

Correspondence to: Dr. Han-Sun CHIANG, MD, PhD, Department of Urology, Taiwan Medical University Hospital, 252 Wu Hsing Street, Taipei.
Tel: +886-2-2737 2181 Ext. 1125, Fax: +886-2-2377 4700
E-mail: hansun@tmu.edu.tw
Received 2001-11-17 Accepted 2002-01-28

ther our investigation on penile anatomy in human cadaver. Since then we have carried out venous stripping surgery based on the anatomical findings with the ultimate goal of surgical improvement.

2 Subjects and methods

2.1 Imaging

Thirty-five patients, who had undergone venous stripping surgery, complained of poor erectile function developed gradually 6 months to 7 years postoperatively. Cavernosography was performed again. In seven new patients undergoing venous stripping surgery, spongiosography and then cavernosography were performed preoperatively. Five patients also underwent intraoperative cavernosography.

2.2 Cadaveric dissection

In eleven cadavers, careful dissection and removal of all tissues superficial to the Buck's fascia was performed under a dissection microscope. A schematic illustration of erection-related veins of human penis was shown in Figure 1. The deep dorsal vein, circumflex veins, para-arterial veins, cavernosal veins, dorsal arteries and dorsal nerves were then freed from the coronal sulcus to the infrapubic angle, which had been exposed with a saw to separate the symphysis pubis. The length of the deep dorsal vein was measured from the infrapubic angle to the coronal sulcus of the glans; to measure its circumference, it was detubularized at the level of the infrapubic angle. Likewise the deep-seated cavernosal vein was identified, traced as distally as possible and measured. Serial sections (2.0 cm) were taken from the tip of the penis and continued proximally until a complete septum was encountered. Each cut surface was examined for the tunica albuginea, the length from positions 9 to 3 and 12 to 6 o'clock, and the neurovascular distribution. Regarding the circumference of the corpus cavernosum (in cm), if A is the length from 9 to 3 and B, 12 to 6 o'clock, the diameter (D) will be (A+B)/2 and the circumference, πD. The circumferential ratio is calculated by adding the circumferences of the deep dorsal and cavernosal veins and then dividing the sum by the circumference of the corpus cavernosum. A tissue block was taken for histologic confirmation.

2.3 Penile vein stripping surgery

2.3.1 Patient population

Since September 2000 we have performed venous stripping according to our anatomical findings in 155 outpatients under local anesthesia. They are followed up with IIEF-5 every three months.

2.3.2 Operation

A longitudinal pubic incision, twice as long as the diameter of the penile shaft, is made. Blunt dissection is carried out to enter the Colles' fascia. The space must be adequate to free the penile shaft, which is then released with an inside-out maneuver (Figure 2A). The deep dorsal vein is ligated with 6-0 nylon as distal as the level of the retrocoronal sulcus, where the number of veinlets could be as high as 29. A milking manipulation is helpful in vascular differentiation. A pull-through maneuver (Figure 2B) of the deep dorsal vein is made step-by-step with its trunk serving as a guide (Figure 2C) by several holes rather than complete opening made on the Buck's fascia. Likewise the cavernosal vein is completely stripped, but in dealing with the para-arterial veins they can only be treated segment by segment. Finally the bilateral crural veins are similarly treated if encountered. The wound is closed with 5-0 chromic catgut and then 6-0 nylon. A compression dressing is placed to encircle the penile shaft, which is stretched as much as possible. Patients are instructed postoperatively to perform pelvic floor exercise once a day, a pull-back force against the glans penis signifying a correct performance.

3 Results

3.1 New and return visit patients

Spongiosography and cavernosography performed in each of the seven new patients suggested that the deep dorsal vein serves as a common vessel of the corpora cavernosa and corpus spongiosum, receiving the blood drained from the corpora cavernosa via numerous emissary veins and from the corpus spongiosum through fewer circumflex veins. In these patients the cavernosal vein (Figure 3) was demonstrable in either the early or late phase of cavernosography, but never in spongiosography. A prominent cavernosal vein with emissary veins were noted without exception in the 35 return visit patients. Of these, 17 were found to have two cavernosal systems, which we have characterized as residual (Figure 4).

3.2 Cadaveric dissection

Table 1 summarizes the venous data of the eleven cadavers. The circumference of the corpora cavernosa ranged from 4.72 to 7.06 cm, the deep dorsal vein from 0.6 to 1.3 cm, and the cavernosal vein from 0.2 to 0.75 cm. It is interesting to note that if the ratio was less than 25.4%, the para-arterial veins were more conspicuous. The ratio between the length of the cavernosal vein and that of the deep dorsal vein was more than 59% in 9 cadavers, but less than 40% in two; thus, 81.8% (9/11)

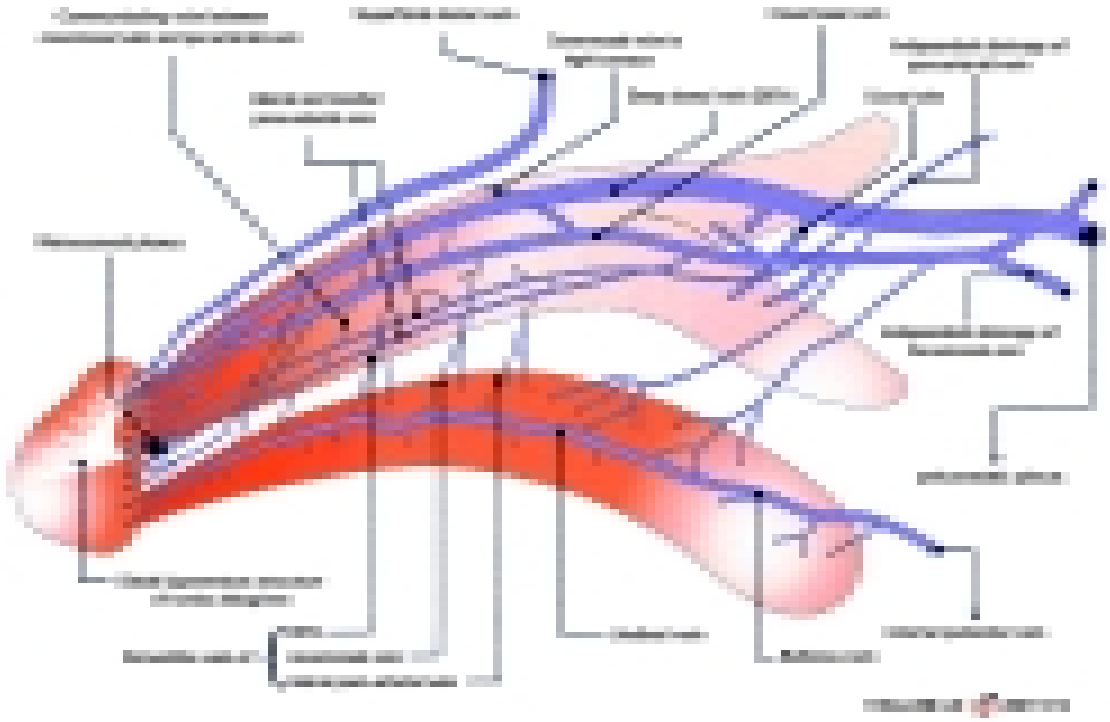

Figure 1. Schematic illustration of erection-related veins of human penis (lateral aspect): The deep dorsal vein, consistently in the median position, receives blood of emissary veins from the corpora cavernosa and circumflex veins from the corpus spongiosum. It is sandwiched by cavernosal veins, that lie in a deeper position. Bilaterally, the dorsal arteries are sandwiched by medial and lateral para-arterial veins. Note that the lateral para-arterial vein merges with the medial one proximally; it is then a very tiny vessel (not demonstrated in this illustration) and accompanies the dorsal artery.

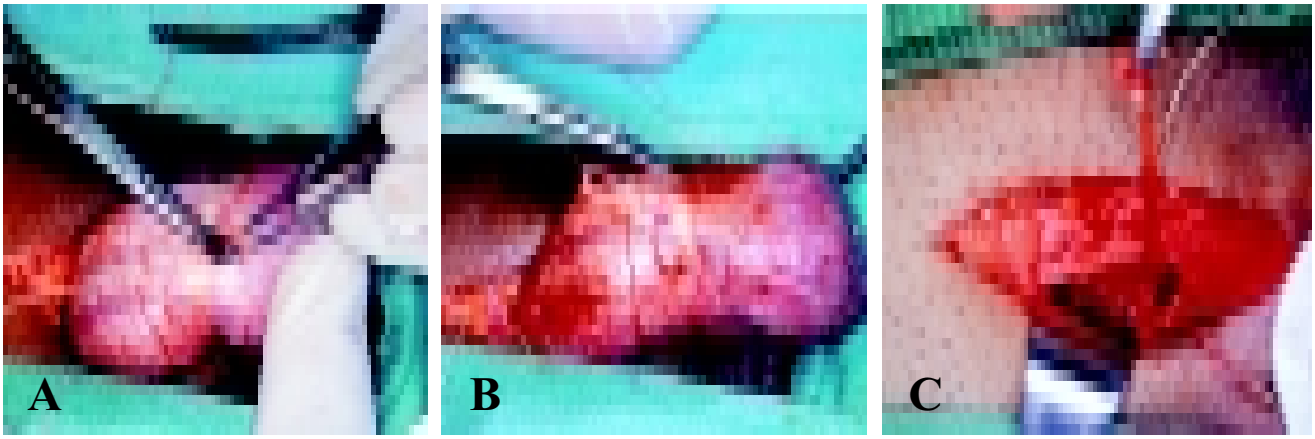

Figure 2. Photographs of venous stripping surgery: A) A longitudinal pubic incision, twice as long as the diameter of the proximal penile shaft, is made. An inside-out maneuver is made to release the pendulous portion of the penis. A milking manipulation (squeeze the sinusoids and venous plexus) is good to enhance the visibility of vein (5-8 smaller veins coalesce to form the deep dorsal vein). Once it is ligated, the retrocoronal plexus shall be stripped thoroughly distal to the sulcus where the number of veinlets can be as high as 29; B) On the Buck's fascia, stepwise holes are made at the exit of the circumflex vein. A pull-through technique (usually requires 3 to 5 times) is applied. A compression dressing is made to encircle the penile shaft to prevent further oozing. C) The trunk of the deep dorsal vein serves as a guide to strip the venous plexus until the infrapubic angle is met. A depth of 3 inches is usually encountered, therefore a right-angle retractor with 3 1/4×5/8 inch blade is mandatory. After the deep dorsal venous plexus is stripped, an always prominent cavernosal plexus should be similarly treated, but the para-arterial vein can only be dealt with segment by segment. In dissection, medial separation is recommended instead of severance to prevent tissue damage.

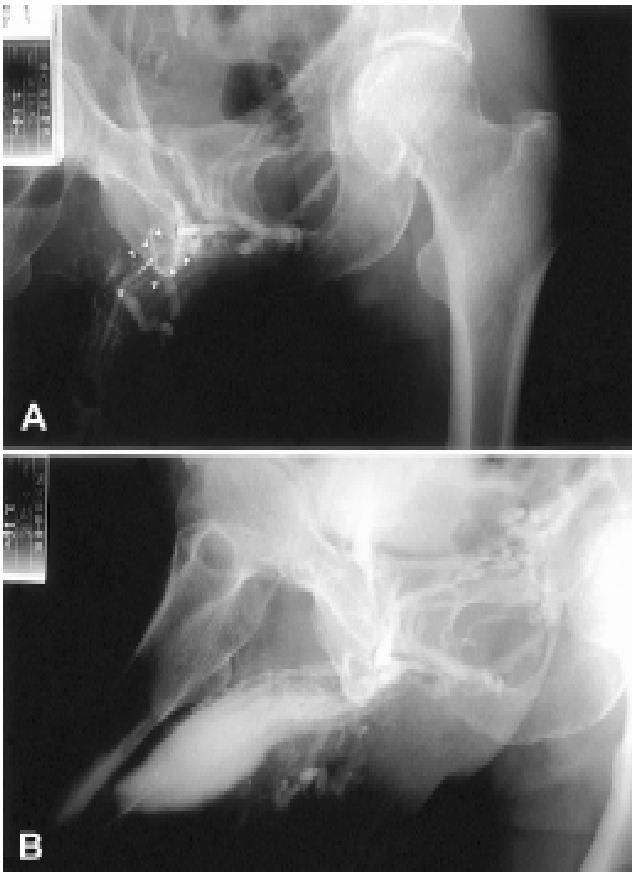

Figure 3. A 83-year-old patient: (A) Early-stage cavernosography film, clearly showing the deep dorsal vein and an exit (white aster) of the circumflex vein. A couple of cavernosal veins (a battery of white arrowheads) sandwich the deep dorsal vein (white arrow). (B) Pharmacocavernosogram, 30 minutes after intracavernosal injection of 20 μg prostaglandin E1, opacification of deep dorsal vein and its circumflex vein signifying veno-occlusive dysfunction.

of the cadavers had a longer cavernosal vein. Indeed, as shown schematically in Figure 1, in 9 of 11 cadavers a cavernosal vein was found to course along each corpus cavernosum distal to the glans, rather than to be merely a short segment at the penile hilum. Table 1 shows that the cavernosal vein was asymmetrical both in its size and course. In all cadavers, two sets of para-arterial veins were found sandwiching the dorsal arteries. These were prominent distally, where the medial one received emissary drainage from the corresponding corpus cavernosum; the lateral one was found occasionally (n = 9) to have its own circumflex vein from the corpus spongiosum. Three cadavers demonstrated an independent drainage proximally, coursing out of the pelvis. However, a tiny para-arterial vein accompanied the dorsal artery into the pelvis.

3.3 Venous stripping

Of the 155 patients undergoing venous stripping surgery, 148 are available for follow up and 5 of them received cavernosography (Figure 5). Their mean IIEF-5 score was 9.3 preoperatively and increased to 22.7 after the operation that remained stationary 6 months after operation. Interestingly, 88.5% (131/148) of the patients believed that venous stripping was a worthy treatment modality. Five cases required sildenafil to maintain their potentia, which was not working preoperatively.

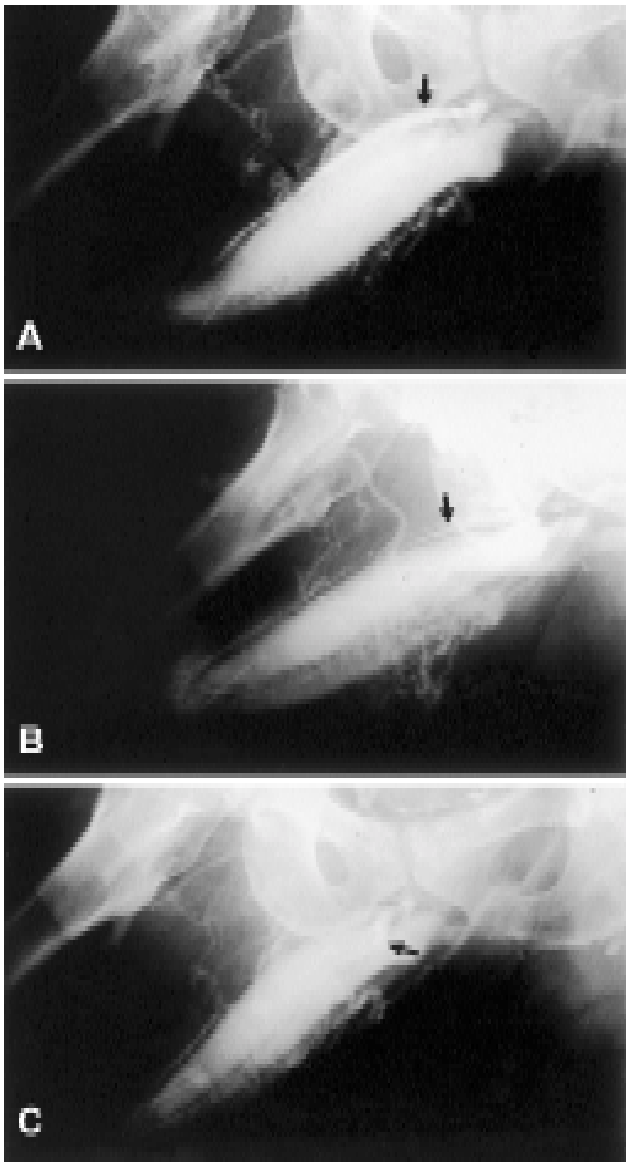

Figure 4. In a venous-stripping patient: (A) Preoperative pharmacocavernosography, showing a huge deep dorsal vein (arrow); (B) Cavernosography 6 months after deep dorsal vein stripped and ligated, showing a residual cavernosal vein (arrow) that was masked on (A); (C) Intraoperative cavernosography, showing a conspicuous left cavernosal vein (arrow), which should be removed, otherwise, poor responsiveness may gradually develop postoperatively.

Table 1. Erection-related penile veins in the cadavers.

No. of cadaver	Circumference (cm)				Predominant side of cavernosal vein	Length (cm)		
	Corpora cavernosa	DDV	Cavernosal vein	Ratio (%)		DDV	Cavernosal vein	Ratio (%)
1	5.02	1.1	0.8	36.9	Left	12.0	> 10	>83
2	5.96	0.8	0.5	21.8	Left	10.6	10.6	100
3	7.06	1.3	0.7	28.4	Left	12.0	> 7.9	>66
4	4.72	0.8	0.4	25.4	Left	11.0	> 6.5	>59
5	5.02	0.9	0.5	27.9	Left	11.5	> 7	>61
6	4.72	1.0	0.4	29.7	Right	11.0	> 8.0	73
7	6.12	1.0	0.2	19.6	Left	10.0	> 3.5	>35
8	4.94	0.6	0.4	20.3	Left	11.0	> 8.9	>81
9	4.94	0.6	0.3	18.2	Left	7.5	3.0	40
10	5.12	0.9	0.6	29.3	Right	10.5	> 6.5	> 62
11	6.30	1.2	0.6	28.57	Left	10.2	7.5	74

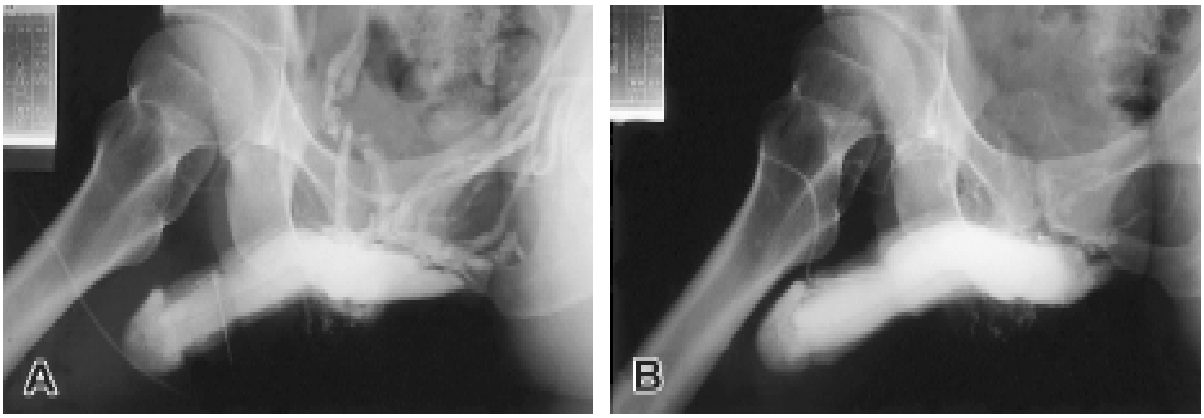

Figure 5. Cavernosography, 29-year-old patient: A) Venous surgery performed around 1997 resulted in improvement in potentia for 5 months only, the proximal stump of deep dorsal vein and cavernosal vein being conspicuous. Veno-occlusive dysfunction prompted him to consult us. B) After venous stripping based on the new technique, the film shows a complete venous removal. Note that the corpus spongiosum is opacified due to the presence of ample amount of blood. Erection is resulted after injection of 45 mL of contrast medium diluted with normal saline.

4 Discussion

The tunica albuginea of the corpora cavernosa is a bilayered structure with multiple sublayers [6] through which the emissary veins traverse. The subtunical venular plexus collects sinusoidal blood and is the origin of the emissary veins. Interestingly, in our dissection the majority of the emissary veins were often found to run in an oblique path between the inner and outer layers of the tunica albuginea, whereas the arteries took a more direct path. It was not unusual to see twin tunnels in one venous chamber located exactly at the transition between the inner circular and outer longitudinal tunical layers.

Although the cavernous vein has been traditionally described in the literature as a short vein, in our study the venous system is found to course almost the entire length of the corpus cavernosum, although distally it becomes smaller. It sends a communicating vein, which may be bigger than itself, to the deep dorsal vein and numerous, albeit small, emissary veins proximally to the corpora cavernosa. It is housed within a different perivascular sheath from that of the deep dorsal vein. Therefore, it deserves the term of cavernosal vein. Once the deep dorsal vein is completely removed, the cavernosal vein becomes very conspicuous (Figure 4). Distally it is prone to bleeding if its removal is attempted, not only because of its relationship to the sinusoids but also its fragility. In addition, the proximity of the cavernosal vein to the corpus cavernosum not only risks bleeding but also makes it difficult for the surgeon to distinguish venous from arterial blood.

The para-arterial veins, found consistently in our eleven cadavers, have heretofore not been reported in the literature. They are always prominent in the pendu

lous portion of the penis; the medial one communicates with the glanular sinusoids and cavernosal vein, and the lateral one with the glans and, in some cases, with the corpus spongiosum directly via its own circumflex vein. During venous surgery, these para-arterial veins become greatly engorged if the cavernous sinusoids are squeezed, implying that a substantial amount of the sinusoidal blood is drained via the emissary veins, which appear to be more prominent during postoperative cavernosography. These veins are regarded as residual rather than recurrent ones as they become very conspicuous as soon as they are left aside during operation (Figure 4).

Venous surgery for erectile dysfunction was advocated as early as a century ago [7-9]. However, many surgeons have now abandoned it because of poor long-term results, which have been ascribed to recurrent veins and intracorporeal defect [10]. Although the offender has been thought to be the deep dorsal vein [11-17], in our study the presence of para-arterial veins and/or a residual cavernosal vein provide the possibility of additional contributory factors. Both the cavernosal and para-arterial veins are vulnerable to be overlooked at the operation. In venous surgery, the deep dorsal vein, as well as the cavernosal vein should be stripped completely, despite the difficulty. However, the para-arterial veins should be treated segment by segment. Any longitudinal tissue, except the veins, is not allowed to be severed (but separated) in the whole procedure, otherwise an irreversible trauma will result.

The number of veinlets at the level of the retrocoronal sulcus varied greatly and could be numerous (Figure 1). These could be seen to merge separately with the deep dorsal vein, cavernosal vein, and para-arterial veins (the last also had communicating veins). Hemodynamically, the result is a pressure-dependent phenomenon in the pendulous portion of the penis, where venous leakage may be initiated clinically. The amount of blood within the penile tissues and the complexity of the venous anatomy (intermingling with arteries and numerous small nerves) discourage surgeons from attempting penile venous surgery. In our experience, asking an assistant to compress the cavernous and glanular sinusoids to control bleeding will facilitate dissection and encourage the complete stripping necessary for operative success. We have applied this anatomical knowledge to our recent venous stripping procedures. A significant improvement of our patients after surgery greatly encouraged us.

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