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RESEARCH ARTICLE

Cavernoscanner: Technique and modelling in erectile dysfunction due to caverno-venous leakage

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Abstract

As a result of technical progress in the exploration of erectile dysfunction by caverno-venous leaks, initiated by conventional radiography under artificial erection, authenticated by ultrasound under pharmacological stimulation, cavernoscanner is proving to be an indispensable tool for their precise localization. The study of 337 consecutive examinations carried out over 5 years (2015-2020) with the Vizua platform made it possible to confirm the initial classification proposed by Virag and Paul, distinguishing between no leakage (A), deep leakage (B), superficial leakage (C), and the addition of deep and superficial leakage (D); and to identify two additional locations: opacification of the corpus spongiosum and leakage from the bottom of the corpora cavernosa. A total of 11.57% had no leakage, giving an efficiency of 88.3% for the orientation by pharmacologically stimulated ultrasound; 20.17% had a deep leakage, of which 10.9% were isolated; 15.3% had a superficial leakage, of which 5.4% were isolated; finally 46% had mixed leakage, of which 20.47% had no communication with the corpus spongiosum and leakage through the floor of the corpora cavernosa. CT scan was performed under pharmacological stimulation and contrast medium perfusion with 3 acquisition passages: filling, state phase and emptying. The study of the native and reconstructed images allows the systematized localizations, the evaluation of the severity of the leakage based on the rigidity obtained and the speed of evacuation with or without bladder opacification. Complications are minor (ecchymosis) and the very rare persistence of a rigid erection (n=3) well controlled by injection of the alpha-blocker etilefrine.

Keywords: cavernoscanner, CT scan, erectile dysfunction, caverno-venous leak, penile ultrasonography, pharmacological stimulation of erection, intracavernous injection, erecion hardness score

Introduction

Erectile dysfunction (ED) is a common disease affecting more than 30% of male population at any age. ED due to caverno-venous leakage (CVL), whether isolated or accompanying other causes of erectile dysfunction, is frequent specially among young adults who disclaim that they are unable to maintain stable and rigid erections to achieve satisfactory sexual life. This creates distressing situations leading to performance anxiety and/ or avoidance of any attempts. In addition CVL very often fails oral medical treatments and even treatments by intracavernosal self-injection (ISI)(1). In such a clinical situation the main question is: which is the origin of the problem. Does the difficulty to maintain erection depends from psychological reasons or is there a mechanical, organically disease? A debate exists since our early works on the matter (4). Existence of abnormal drainage from the cavernous bodies has been demonstrated in animals (5). Young men suffering from a soft penis are prone to have the same kind of anomalies. We have built a consistent protocol to evaluate thoroughly the existence and severity of those anomalies. First of all when the clinical history evokes such the gold standard tool is ultrasound after pharmacological stimulation (USPS) (2), When highly suspected through this exam (91% efficacy); CVL is visualized by the cavernoscanner also performed under pharmacological stimulation. These two examinations are indissociable because they are performed with an identical methodology anticipating a totally rigid erection in a man without erectile dysfunction. The USPS will give hemodynamic information, the cavernoscanner will locate the origin of the leaks and their destination with precision. Both are essential to discuss a vascular intervention. The aim of this work is to recall the examination technique, the typical images collected and to propose a model of the examination, already outlined in the original work on the subject. (3).

Patients and Methods

The cavernoscanner consists of a CT scan carried out on patients suspected of having CVL based on the following clinical elements: young age of the subjects with ED or long duration of the symptom, positional instability of the erection, resistance to oral treatment but above all detection within the framework of multidisciplinary exploration (4) during the USPS of a CVL with a venous score>1*)(2)*

Practical implementation: on a subject who has been fasting for four hours, prior intracavernous injection (IIC), in an isolated preparation room, of the same dose of vasoactive medication as during the USPS; after 15 minutes of waiting: measurement of the erection hardness score (EHS (6) (Table 1) and transport to the X-ray room where a butterfly 21G is placed in the distal 1/3 of the penis, on its lateral edge at a 30° angle, one finger below the balano preputial groove. The CT acquisition (*Siemens Somaton perspective 64-row detector)* is performed by spiral scan, automatically injecting 20 to 80 ml of a contrast product (*iopamidol),* diluted to 30% in saline. The images of the penis and its possible venous drainage are collected and

reconstructed during three distinct acquisition phases: 1- a *filling* phase during which 10 ml of contrast product is injected at a flow rate of 0.8 mL/sec; 2- a *cavernous* or emptying phase during which 10 to 60 mL are injected; 3- an *emptying* phase 10 minutes after the contrast product perfusion is stopped and the catheter is opened. At the end of the examination, the catheter is removed and a compression bandage is applied, while monitoring the disappearance of rigidity. If rigidity persists, an injection of 0.6 mL of *etilefrin* (SERB Paris France) is performed. The level of irradiation is specified during each examination including the DLP in mGy/cm (on average 600 to 700 Gy/cm) and the CTDI volume (on average 7 to 8 mGy). At each stage the EHS is evaluated from 0 to 4 and the maximum score retained. MIP and reconstruction are evaluated by the radiologist (PH) and then transmitted to a platform or an expert software (SO) will process the images in 3D (volume rendering) (*Vizua 3D-Monaco Tech S.A.M.98000Monaco).* They are available in 48 hours on any digital medium, accessible to clinicians (HS, RV and EA) for dynamic evaluation and modelling.

Modelling: Each scan is seen by the radiologist (PH), then reviewed on the Vizua platform by two of us (HS and RV). The three CT scans are examined to evaluate and locate deep (figure 1), superficial (figure 2 A and B), by the bottom of the corpora cavernosa (figure 3), communication with the corpus spongiosum (either isolated in the glans penis) or with the entire corpus spongiosum (figure 4 A and B). In addition, the presence or absence of bladder opacification is assessed on the *emptying* time (Figure 5b). Its presence, more or less intense, indicates the importance of the leakage. At the end of this evaluation the leaks are classified according to the classification of Virag and Paul (3): A-no leakage; B-isolated deep leakage; C-isolated superficial leakage; D-mixed deep and superficial leakage (figure 6). When opacification of the corpus spongiosum (E) and/or leakage of the fundus (F) is found, the initial E or F is added to the letter characterizing the main leaks. The recorded results will be compared with the USPS data and the clinical condition of each patient. Simple statistical analysis has been performed to analyze percentage of patients belonging to each groups and compared to the USPS results.

	4: Full rigidity 3: Rigid but flexible 2: Tumescent 1: Just filled 0: Unchanged

Table 1 The Erectile Hardness score

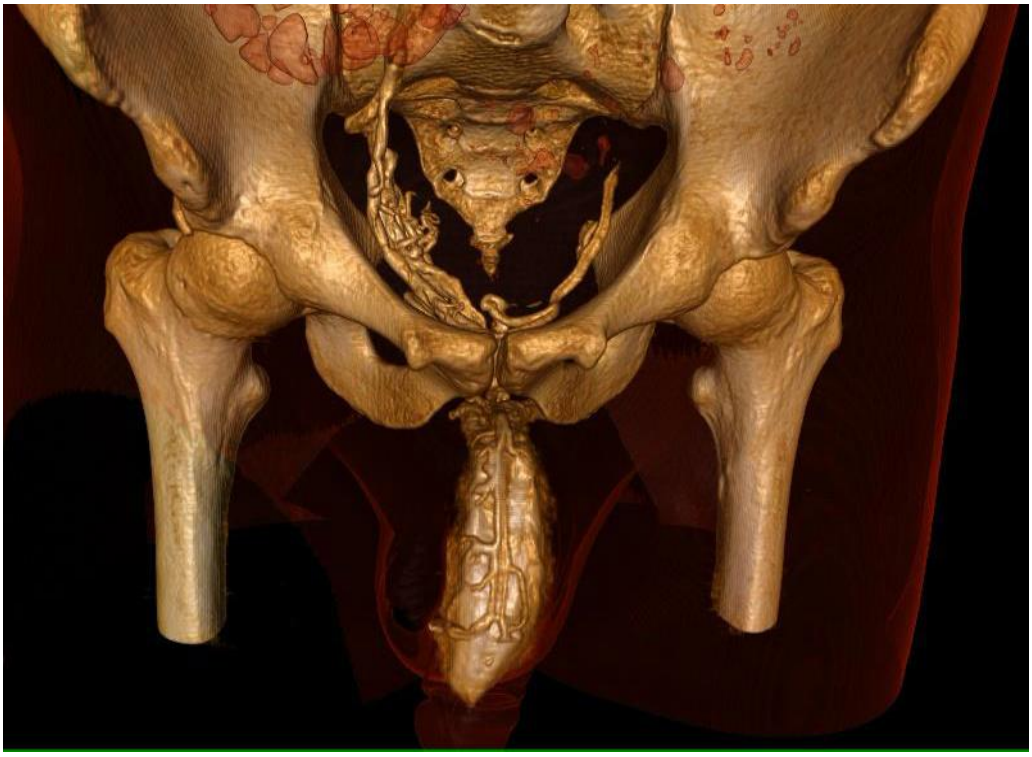
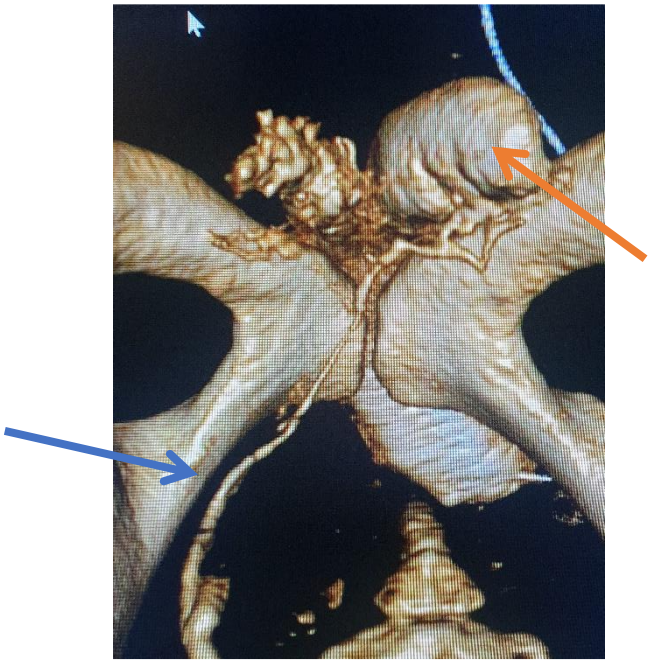


Figure 1: Venous leakage through the deep dorsal network (Virag and Paul's Type B) The VDP drains into the plexus of Santorini. Erection Hardness Score = 2

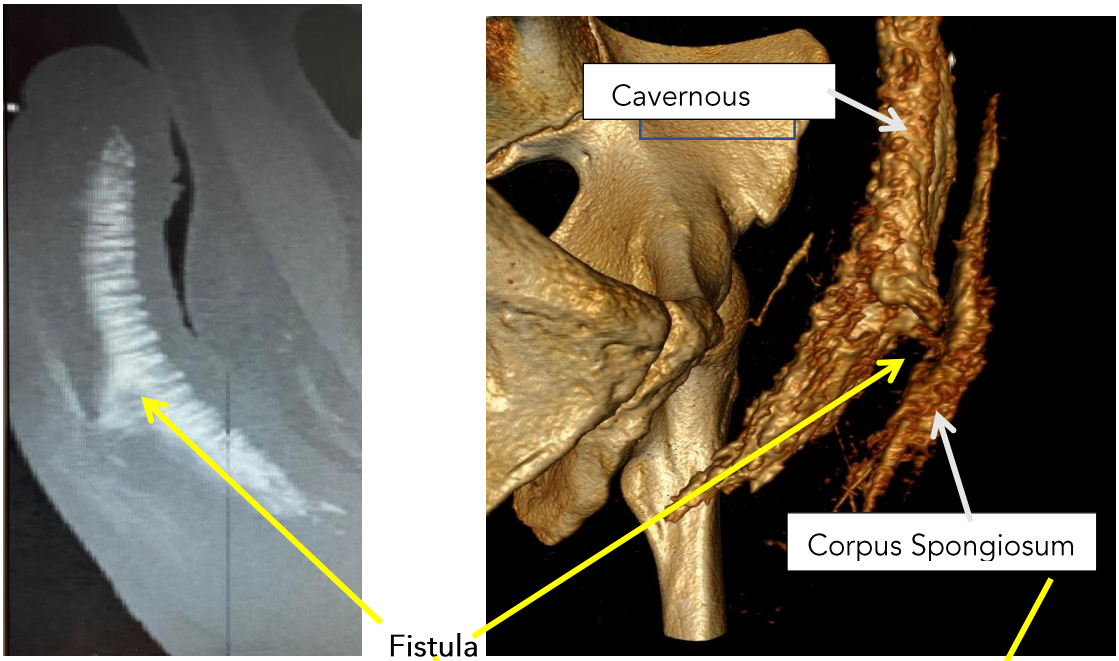
2-A Unilateral superficial leak (Virag and Paul type B) The normally blocked PWV (arrow and figure 7) under the pubic symphysis drains into the great saphenous vein

2-B Bilateral superficial leakage The Deep Dorsal Vein (DDV) divides into 2 branches draining into the 2 femoral veins. No deep leakage (Type2 Virag and Paul)

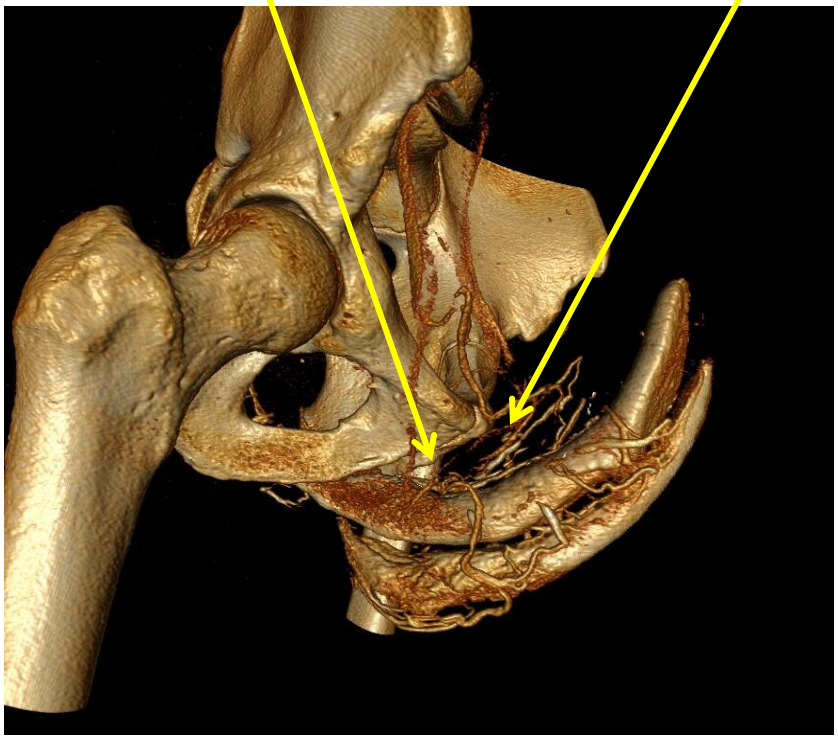


3-A Leakage from the crura of the left corpus cavernosum (posterior view) orange arrow Drainage to the right internal iliac vein

3- B Massive leakage from the crura of the right corpora cavernosa into the plexus of Santorini . Postoperative control after incomplete result of a first operation< ;

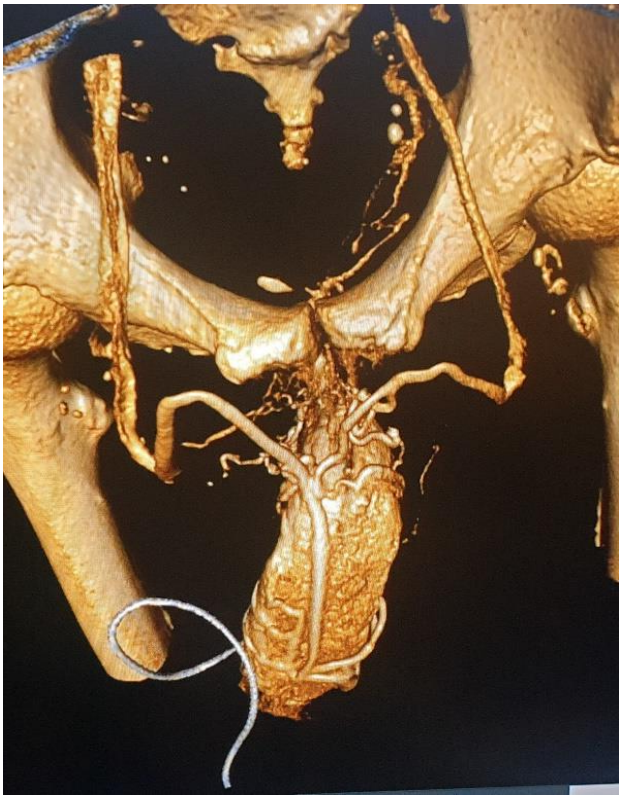


A- *B-*



C-

Figure 4 An example of leakage between cavernous body and corpus spongiosum
A- MIP image of the filling B- 3D reconstruction of this image C- Complete filling with significant opacification of the cancellous body



A- Bilateral superficial leak (2nd stage of the scan)

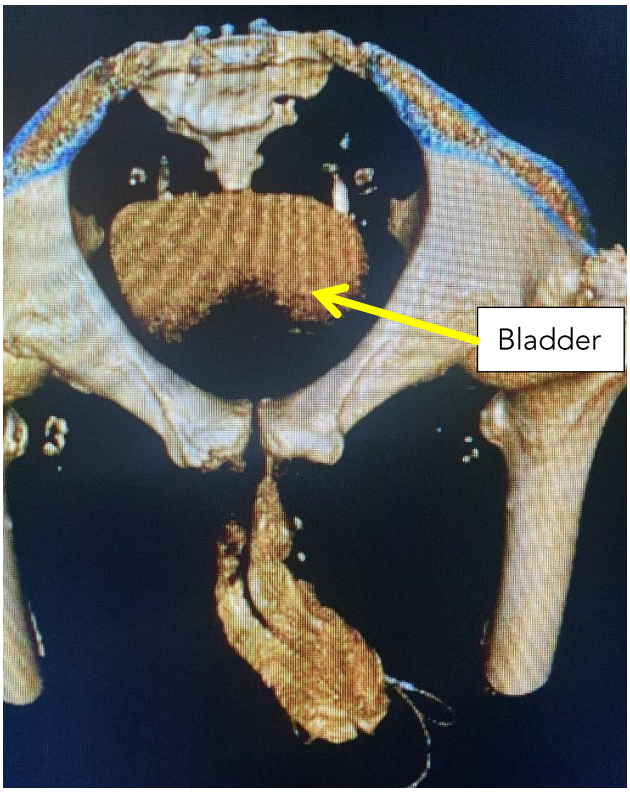


Figure 5 in A- Large superficial leakage; in B- Emptying time with massive bladder opacification indicating a large leakage

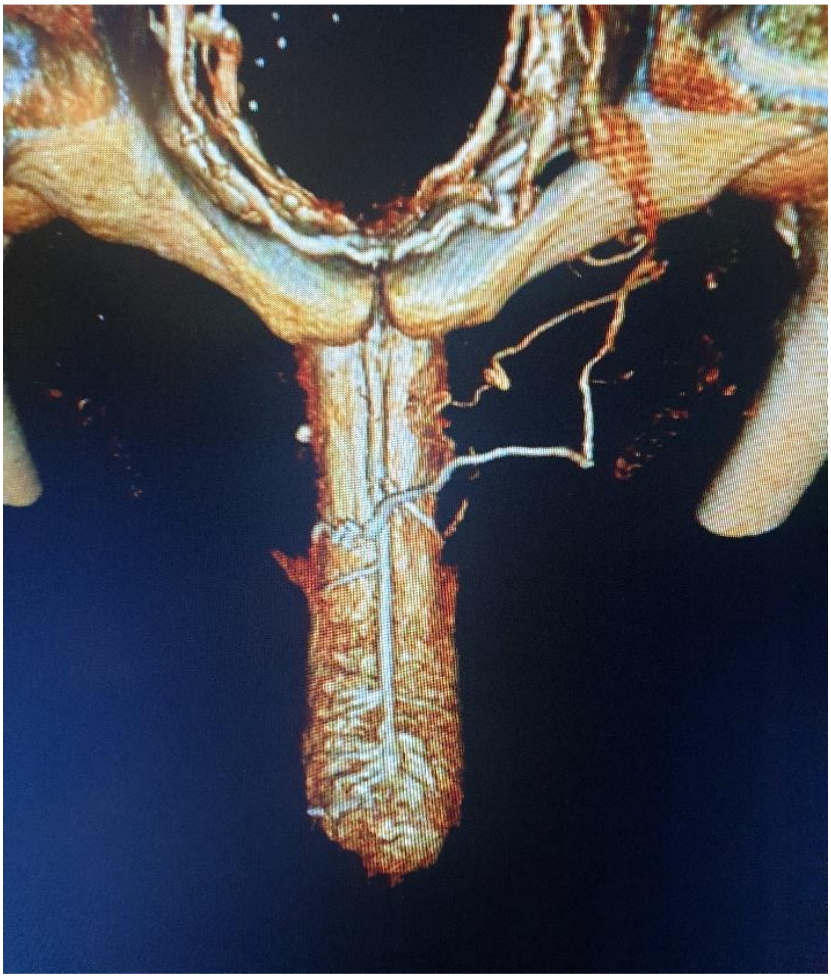
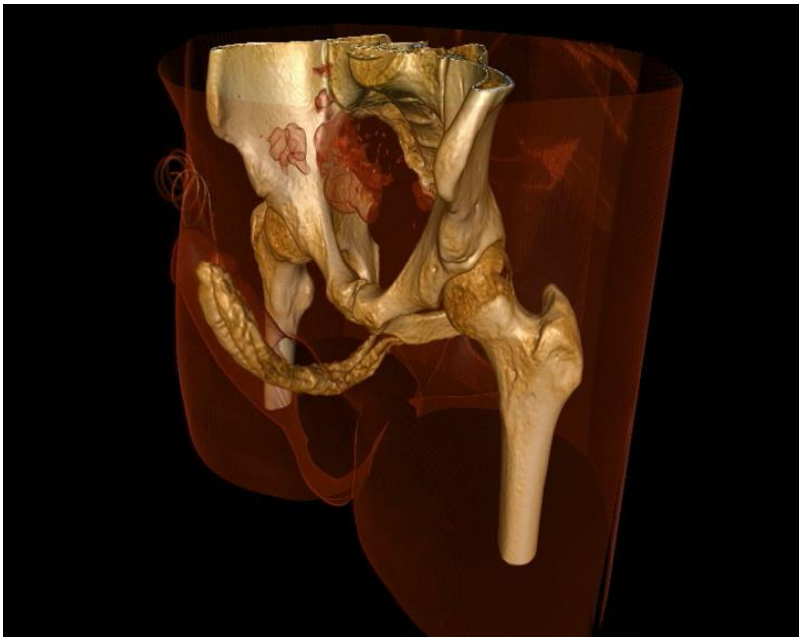
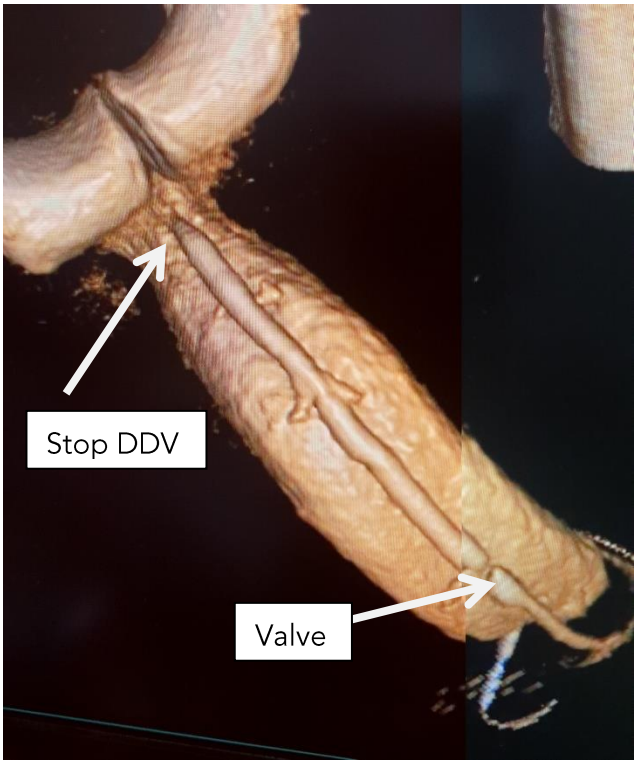


Figure 6: Mixed superficial and deep leakage (Virag and Paul type D): superficial drainage to the left femoral vein and drainage of the deep dorsal vein to the left femoral axis



A-



B -

Figure 7 Virag and Paul's "normal" Cavernoscanner Type A

A- No visible opacification: intracavernous venous blockage

B- Visualization of the deep dorsal vein blocked under the pubic symphysis (double play of the Houston muscle and the suspensory ligament. Note the presence of a valve (the DVM has 5 to 7 valves)

Results

Data from 337 scans performed between 2015 and 2020 following the protocol described above, were blinded by HS and VR without taking into account the clinical history and then compared with the results of the USPS and the reading of the CR done independently by PH. The data set is shown in Table 2. Only 163 patients (48.36%) fit strictly into the Virag and Paul classification. The remaining 174 (51.6%) had additional CS opacities (n=106) and/or CC leakage (n=68). The patients classified as pure A (n=39, i.e. 11.6% of the cohort) are patients with no CVF at all (figure 7), once the cases classified as A (n=63) have been deducted, but in whom an opacification of the CS or a leak through the bottom of the CC has been detected. Just over 20% had deep VF, almost equally divided between pure deep leakage or leakage associated with CS or FCC. SVLs are identified in 15.1% of cases, of which only 5% are isolated SVLs *superficial venous leaks in this issue).* Finally, deep leaks represent the majority (52%) of identified VLFs, 45% of which are without CS or FCC. When confronted with these results, the USPS identified the leak in 88.4% of cases (2). The examination was free of severe complications: two patients who presented a lasting rigid erection at catheter removal received an injection of etilefrine to obtain detumescence. Ecchymosis or hematomas were reported; more frequently they disappeared in a few days without leaving any after-effects.

Ranking after Cavernoscanner Nature of the leak	Isolated	+ Crura leakage And or CS	% OF TOTAL
A	39	24	18,69
B	37	31	20,17
C	18	33	15,13
D	69	86	45,99
Total	163	174	

Table 2 *Classification of data from 337 cavernoscanners*
In red the number of cavernoscanners strictly without leakage (11.5%)
CvL = corpus cavernosum fundus CS = cavernosal communication to corpus spongiosum

Discussion

ED being very common as mentioned above their etiology is frequently misdiagnose specially in the below 40Y age group where patients are sent home with a sildenafil pill, and a current comment telling: "It is all in your head". This sentence keep many patient desperate specially when they do not respond to any conservative treatment such as phosphodiesterase inhibitors (PDE5) or intracavenous injection of vase-active medications. It is nowadays assumed that more than 30% of the patients do no respond favorably to those treatments. The necessity of a thorough evaluation of the mechanisms of ED is mandatory (3). When a CVL is suspected the couple USPS / cavernoscanner is mandatory. Medical imaging of the human erection began with conventional radiography by opacifying the corpora cavernosa of a rigid penis using artificial erection (8). This allowed the identification of CVL without any fine anatomical precision, but allowed a better understanding of the hemodynamics of t erection. With the discovery of the action of papaverine (8), a simplification of the evaluation became possible and only the patients presenting with ED refractory to the treatment by ICI were explored. However, it was with the advent of CT scanners and the increasing sophistication of USPS that the cavernoscanner was proposed (3). The quality of the information obtained depends on the rigorous observance of the proposed protocol and particularly on the concordance of the product used and its identical dosage for the two ultrasound and radiological investigations. Thus, it was reported in a previous work (2) that with this rigor only patients with real CVL detected by USPS(venous score>1) are referred to cavernoscanner with a view to surgical treatment of CVL *(9)* . The Vizua system (volume rendering) applied to the reading of cavernoscanner scans has allowed an in-depth study of the images collected. In particular, it has brought an important additional notion, the presence of frequent opacification of the corpus spongiosum and the identification, previously unknown, of leaks from the crurae (figure 4). As far as the former are concerned, for the moment only well-identified communications of leaks from the CC to the CS are retained (figure 5). They are generally post-traumatic. The role played by the corpus spongiosum in erectile mechanics is still unclear. As far as leakage through the crurae is concerned, it is often hemodynamically significant and responsible for clinical recurrence of ED, when it is ignored during venous surgery (10,11). With Vizua and in parallel with native CT images and USPS data, the identification of the topography of CVL is progressing enormously, also in relation to the important work of Gen Long Hsu's team(11). Based on this observation, the therapeutic indications and in particular surgical indications are increasingly refined and lead to a systematization of the indications (8).

Conclusions

The cavernoscanner has become an essential instrument for the exploration of ED by FCV identified by the USPS. Digitization, volume rendering of the Vizua° system making it visible to all in virtual reality augurs important progress in the understanding of CVL and in direct and/or endovascular reconstruction surgery.

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