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ORIGINAL PAPER

Penile vascular diagnostic categorization using penile duplex Doppler ultrasound: Differences in vascular hemodynamics parameters by differences in anatomic sampling location

Fabio Pezzoni [1], Fabrizio Ildefonso Scroppo [2]

[1] Vascular Surgeon, University of Milano, Italy-member of SIA, Italy;
[2] Department of Urology and Andrology, UOC Urology Ospedale di Circolo, Varese, Italy.

Summary *Objectives. In 2013 the International Society for Sexual Medicine(ISSM) published the guidelines regarding the standard operating procedure (SOP) for penile duplex Doppler ultrasound (PDDU). Although ISSM-SOP have given important strides in reducing interobserver variability in PDDU by procedural protocol and parameters these guidelines do not address the anatomic location along the penis at which hemodynamic measurements have to be done. In our opinion a "double sampling" may be interesting to detect the arteriogenic or venogenic nature of the erectile dysfunction (ED). In particular sampling measurements at the "crus" (at the level of the peno-scrotal junction) may be significative for detection of veno-occlusive dysfunction (VOD),whereas an evaluation at "mid penis" (1/2 distance between peno-scrotal junction and coronal sulcus), may be useful to diagnose an arterial insufficiency (AI).*
Material and Methods. We evalued 90 men, mean age 56.3, affected with ED of medium degree, responder to PDE5-I that urdergone to PDDU and also responder after pharmacologic intracavernosal injection (PII)of prostaglandin E1 20 mcg, with rigid erection and normal maintenance. We moreover evalued 90 men in youthful age (mean 35.2), in absence of vascular risk factors, no responder to PDE5-I that undergone to PDDU by PII at high dosage (bimix: prostaglandin E1 20 mcg, papaverine 20 mg).
Results. In the first pool the sampling at "mid penis" resulted significative for arterial insuffciency (AI) in 81% (73), in presence of normal or borderline end diastolic velocity (EDV). Sampling at the "crus" resulted negative for VOD in 90% (81). In the second pool, 66.6% (60) resulted responder with rigid erection and normal maintenance in presence of normal hemodynamic parameters: peak systolic velocity (PSV) and end diastolic velocity (EDV) both at the "crus" and at "mid penis" sampling. 33.4% (30) responded with a semirigid erection and manifested a constant deficit of maintenance; at the "crus"and at "mid penis" the hemodynamic arterial parameters resulted normal. At the "crus" the EDV resulted significantly augmented (VOD index) in 96.6% (29); at "mid penis" augmented EDV was founded in 50% (15).
Conclusions. These observational data would be able to confirm the utility of a routinary "double sampling" procedure, at the "crus" and at "md penis", during PDDU in order to better distinguish between VOD or AI or in any case to be useful to stimulate a future more precise standardization in execution of PDDU examination.

KEY WORDS: *Duplex Doppler ultrasonography; Erectile dysfunction; Penile venous leakage; Arteriogenic impotence.*
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INTRODUCTION

Erectile dysfunction (ED), together with premature ejaculation, is the most common male sexual disorder. Vascular ED comprehends cavernosal artery insufficiency and dysfunction of penile veno-occlusive system. These two mechanisms frequently cohabit in a single patient, representing two different steps of the same disease. It is demonstrated that around 70% of all ED is related to pathological penile vasculature either through reduced inflow or augmented outflow (1). The recent American Urological Association (AUA) guidelines on ED counsel, in selected patients, a second level vascular diagnostic evaluation (2, 3). The classic test consists in penile duplex Doppler ultrasound (PDDU) after pharmacologic intracavernosal injection (PII) inducing erection, to discriminate arterial insufficiency (AI) and veno-occlusive dysfunction (VOD) from other causes of ED. In 2013 the *International Society for Sexual Medicine* (ISSM) published the guideline regarding the standard operating procedure (SOP) for PDDU (4). Although ISSM (SOP) have given important strides in reducing interobserver variability in PDDU by precise procedural protocols and parameters, these guidelines do not address the anatomic location along the penis at which
hemodynamic measurements have to be done, during the execution of the examination. PDDU is aimed at the functional and anatomical study of the cavernosal arterial inflow. When vascular evaluation is indicated PDDU offers the least invasive and accurate data to assess the penile arterial inflow. The parameters to estabilish the integrity of the arterial flux are: peak systolic flow velocity (PSV), cavernous arterial diameters, acceleration time. PDDU also can values the cavernous veno-occlusive mechanism in the post-injection phase, considering the end-dyastolic velocity (EDV) and the resistance index (RI); persisting diastolic blood flow and/or low RI: suspect of VOD. A recent study by *Pagano* has pointed out the importance of the differences in vascular hemodynamics parameters by differences in anatomic sampling location of ultrasound probe placement for cavernosal arteries during dynamic PDDU (5). In our opinion a "*double sampling*" may be interesting to detect the arteriogenic or venogenic

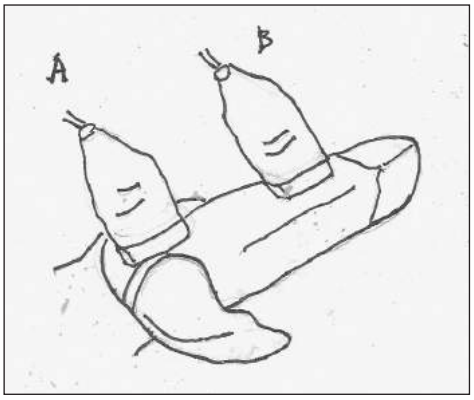

Figure 1. *Crus and mid penis.*

nature of the vasculogenic ED (6, 7). In particular sampling measurements "*at the crus*" (at the level of the penoscrotal junction) may be significatives for detection of VOD, whereas an evaluation at "*mid penis*" (1/2 distance between penoscrotal junction and coronal solcus), may be useful to diagnose an arteriogenic insufficiency (Figure 1).

Material and methods

We evalued a total of 90 men, mean age 56.3, affected with persistent ED of medium degree (IIEF score between 10 and 15), in absence of Peyronie's disease, responder to PDE5-inhibitors that undergone to PDDU and also responder after PII with rigid erection and normal maintenance (8).

According to the *International Consultation on Sexual Dysfunction*, ED is defined as "*persistent*" when there is inhability to attain and mantain an erection sufficient to permit satisfactory sexual performance and the symptoms have to persist for a minimum duration of six months. They took PDE5-inhibitors (vardenafil or tadalafil) at personalized dosage after an evaluation "*case for case*" based on: clinical factors, age, frequency of sexual intercourse, life style. PDDU assessments were done using a 12 MHz linear array transducer, after PII of prostaglandin E1 20 mcg. Parameters that have been considered for a vascular diagnosis were PSV, EDV, acceleration time and RI. PSV was considered normal for mean values > 30 cm/sec.; EDV for values < 5 cm./sec., acceleration time for values < 1 sec. To reach PSV, and RIhad to be > 0.80, according to ISSM (SOP) (4). We moreover evalued 90 men in youthful age, mean 35. 2, in absence of vascular risk factors, no responder to PDE5-inhibitors (vardenafil e/o tadalafil) in satisfactory way, also at maximum dosage. They undergone to dynamic PDDU by PII at high dosage of "*bimix*": prostaglandin E1 20 mcg. + papaverine 20 mg.

The same PDDU vascular parameters were also analyzed in this group. In all the cases the examinations were performed by a "*double sampling*" measurements positioning the probe "*at the crus*" (at the level of the penoscrotal junction) and at "*mid penis*" (1/2 distance between penoscrotal junction and coronal solcus) with the aim to postulate the arteriogenic or venogenic nature of the vasculogenic ED.

Results

The sampling, in the first group of men at "*mid penis*" resulted significative for presence of AI in 81% (73): the mean value of PSV was 25.3 cm/sec. (Figure 2). EDV resulted normal or borderline in all the patients (mean 2.1 cm/sec.), acceleration time resulted significative for presence of angiosclerosis in all the men (mean 1.5 sec.), RI had a mean normal value of 0.92 (9) (Figure 3).

Sampling at the "*crus*" resulted negative for DVO in 90% (81): mean EDV resulted 2.5 cm/sec. An EDV value > 5 cm/sec. is considered by ISSM-(SOP) a significative DVO presence index (9) (Table 1).

In the second group of men 66.6% (60) resulted responder with rigid erection and normal maintenance in presence of normal hemodynamic parameters: PSV, EDV, RI both at the "*crus*" and at "*mid penis*" sampling (10). 33.4% (30) responded with a semirigid erection and manifested a constant deficit of maintenance; at the "*crus*" and at "*mid penis*" the hemodynamic arterial parameters resulted normal (Figures 4, 5).

At the "*crus*" EDV resulted significantly augmented (DVO index) in 96.6% (29) with a mean value of 7.8 cm/sec.; RI also had a DVO significative mean value of 0.71. At "*mid penis*" augmented EDV was founded in 50% (15) (11) (Figure 6) (Table 2).

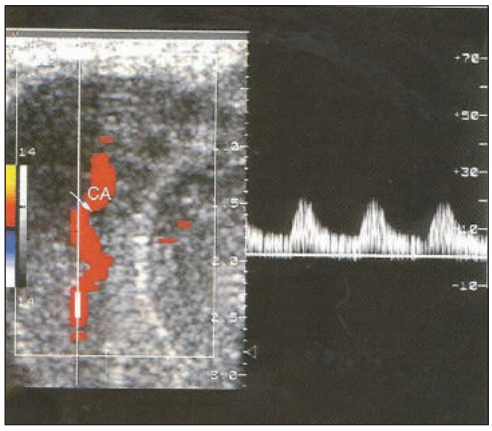

Figure 2. *Arteriogenic insufficiency.*

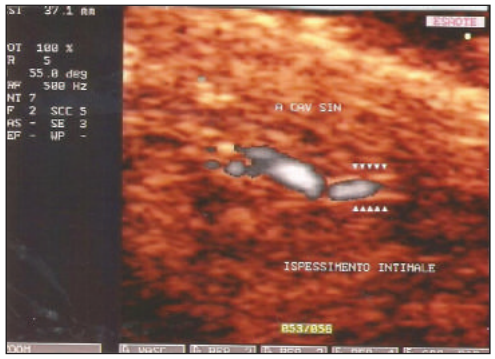

Figure 3. *Angiosclerosis.*

Table 1.
First pool of patients (90).

Sampling "mid penis"	Sampling at the "crus"
Positive for AI: 81% (73)	**Negative for VOD: 90% (81)**
EDV: normal/borderline 100% (90)	

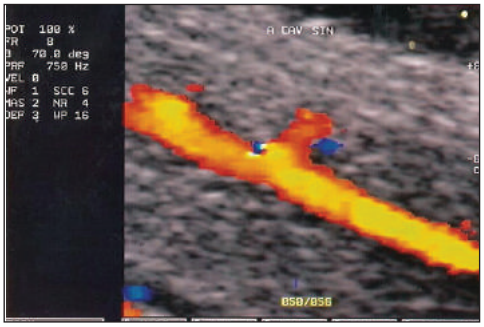

Figure 4. *Normal cavernous artery.*

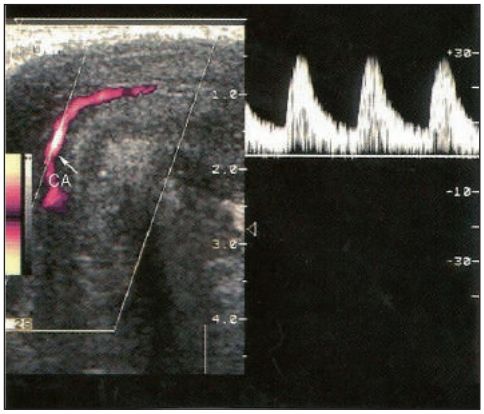

Figure 5. *Normal arterial parameters.*

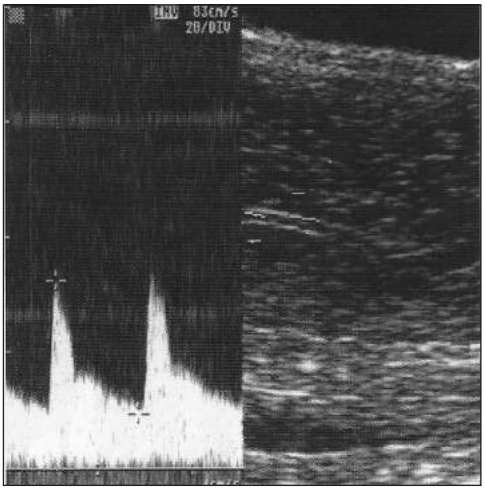

Figure 6. *Edv augmented (DVO).*

Table 2.
Second pool of patients (90).

Sampling at the "crus"	Sampling "mid penis"
Positive for VOD: 96.6% (29)	Negative for AI: 100% (90)
Negative for AI 100% (90)	

Discussion and conclusions

VOD is not classified in a precise nosologycal condition, but like a multifactorial ethiology syndrome and the the "*venous-leakage*" constitues a complex fenomenon interesting structural abnormalities in corpora cavernosa and/or in the tunica albuginea. However these oservational data would be able to confirm the utility of a routinary "*double sampling*" procedure (at the "*crus*" and at "*mid penis*") during PDDU in order to better distinguish between venogenic or arteriogenic vasculogenic disorders or in any case to be useful to stimulate a future more precise standardization in execution of PDDU examination.

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Correspondence

Fabio Pezzoni (Corresponding Author)
Tel. ++39.333.40.36.098
fabiopezzoni1@alice.it
Vascular Surgeon, University of Milano
V. G. Pezzotti, 36 - Milano

Scroppo Fabrizio I., MD Member of SIA
fabrizio.scroppo@ospedale.varese.it
Department of Urology and Andrology,UOC Urology Ospedale di Circolo, Viale L. Borri, 57 - Varese, Italy