# Differences in Cavernosal Artery Parameters According to Different Anatomic Sampling Locations During the Diagnosis of Vascular Erectile Dysfunction Using Duplex Ultrasound

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**OBJECTIVE** To establish a standard location for examining penile cavernosal arteries (CAs) using dynamic duplex Doppler ultrasound (PDDU) examination in the diagnosis of non-arterial erectile dysfunction (ED) or arterial insufficiency.

**PATIENTS AND METHODS** Two groups of 105 patients each were enrolled. The first group (age 56.3 ± 6.0 years) displayed clinical patterns of arterial insufficiency; the second group (age 35.2 ± 4.7 years) displayed clinical patterns of non-arterial ED. The patients had their peak systolic velocity (PSV), end-diastolic velocity (EDV), resistive index (RI = PSV − EDV/PSV × 100), and acceleration time of the CAs measured using PDDU at the crura and at the midpoint between the penoscrotal junction and the coronal sulcus (mid penis). Intra- and interoperator variability were assessed. The PSV, RI, acceleration time, and EDV data obtained from the penoscrotal junction or from the "mid penis" in group 1 and in group 2 were compared using analysis of variance.

**RESULTS** The PSV, EDV, and acceleration time were significantly higher when measured at the crura penis than when measured at the "mid penis" in both groups, whereas the RI was higher at the "mid penis" than at the "crura." Thus, arterial ED was better diagnosed with the data from the mid penis, whereas non-arterial ED was better diagnosed at the "crura."

**CONCLUSION** The location of the sampling site of the CAs using PDDU is critical for a correct diagnosis of ED. UROLOGY 105: 33–41, 2017. © 2017 Published by Elsevier Inc.


Approximately 45% of the patients presenting at andrological outpatient clinics complain of erectile dysfunction (ED); of these, approximately 70% displayed increased venous outflow or reduced arterial inflow.[1] The American Urological Association has stated that vascular assessment may be indicated in selected patients[2] and that duplex Doppler ultrasound (PDDU) of the penile cavernosal arteries (CAs) after intracavernous injection (ICI) of vasoactive drug(s) is the standard method for assessing arterial and venous flow. Peak systolic velocity (PSV), end-diastolic velocity (EDV), and the resistive index (RI = PSV − EDV/PSV × 100) are the parameters currently used for assessing vascular function.[3] There are no uniform standard operating procedures (SOPs) in performing PDDU, resulting in high variability in data expression and interpretation when comparing results among various centers. Establishing SOPs was the objective of a recent study.[4] However, SOPs do not specify a standard anatomic location for CA imaging.[5] There is notable variation of the arterial patterns measured using PDDU depending on the site of Doppler imaging; this can often sway the clinical diagnosis. The EDV was not significantly modified when measured at the crura or at the midpoint between the penoscrotal junction and the coronal sulcus. On the other hand, the PSV significantly decreased from the crura to the coronal sulcus.[6]

The values that PSV displayed along the CAs and the method of calculating the RI allowed us to hypothesize

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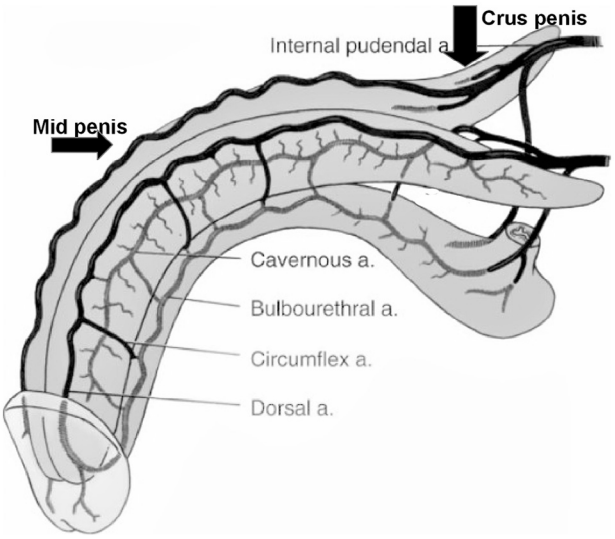


**Figure 1.** Different anatomic sampling locations for the diagnosis of vascular erectile dysfunction using duplex ultrasound: crus penis or mid penis. a., artery.

that PSV and EDV assessments at the crura might be particularly useful for the diagnosis of non-arterial ED (NAED), whereas PSV measurement at the mid penis might be particularly useful for detecting CA insufficiency.[6] This prospective multicenter study was carried out to pinpoint the most useful locations (crura penis or mid penis) for measuring the EDV and the PSV of the CAs to diagnose NAED or arterial insufficiency. This research studied 2 different ED populations using PDDU; the first population had the clinical and anamnestic patterns of arterial insufficiency and the second had those of NAED (Fig. 1).

## PATIENTS AND METHODS

### Inclusion Criteria

This was a multicenter prospective study. Each patient with persistent ED using phosphodiesterase 5 inhibitors (PDE5is) was considered a candidate.

Persistent ED indicates a condition lasting for at least 6 months, in which the patient is unable to attain and maintain an erection sufficient for permitting satisfactory sexual intercourse.[7] The International Index of Erectile Function (IIEF-15) test was administered to each patient; a total score greater than 26 was considered to be indicative of satisfactory sexual function.[7] Only patients with severe to moderate ED (IIEF-15 score < 15) were taken into consideration.

The patients had their acceleration time (AT), PSV, and EDV of the CAs measured using PDDU.

The first group enrolled patients having patterns of arterial insufficiency, that is, the presence of specific risk factors[8]; a response to PDE5is that was considered to be subjectively satisfactory (responders)[9]; and achievement of an erection, the hardness of which was judged by the investigator to be sufficient for vaginal penetration (target erection) after ICI of alprostadil (prostaglandin E-1 [PGE1]) 20 μg.[10] The PDDU data from these patients were collected after 1 ICI with PGE1, 20 μg.

The following were considered risk factors for arterial ED: hypercholesterolemia (>200 mg/dL), hypertriglyceridemia (>175 mg/dL), smoking habit (>10 cigarettes per day), alcohol habit (daily consumption > 0.18 g/kg), uncompensated hypertension (diastolic pressure > 90 mm Hg), obesity (body mass index > 30), and age over 50 years.[8]

The erectile response after ICI was graded as follows in all the patients studied: (1) insufficient for vaginal penetration, (2) sufficient for vaginal penetration, or (3) excellent rigidity lasting at least 20 minutes.[11]

The second group enrolled patients having patterns of NAED, namely, age under 40, absence of any risk factor for arterial ED, failure to achieve a target erection after a first ICI of PGE1 20 μg but achievement of a target erection after a second ICI of PGE1 20 μg + papaverine 20 mg (bimix),[8] and a subjective judgment of insufficient erectile response after correct assumption of at least 2 different PDE5is at the maximum admitted dosage (PDE5is nonresponders).[12]

### Exclusion Criteria

The exclusion criteria were history of any other sexual disease apart from ED (128 patients); refusal of the study protocol (192 patients); Peyronie disease, congenital penile curvature, or penile trauma (53 patients); penile piercing or surgery (8 patients); drug abuse (17 cases); absence of a stable (>1 year) heterosexual relationship (359 patients); and hormonal alterations (28 cases).

### Enrollment, Assessment of the Study Subjects, and Sample Size

Enrollment began on January 2, 2016, and ended on May 31, 2016.

Each patient participating in the study underwent the following assessments: clinical history collection, objective examination, body mass index (weight in kg/height$^2$ in m), blood pressure measurement, blood count, blood sugar (normal range: 70-110 mg/dL), glycated hemoglobin (normal values < 6%), total cholesterol, low density lipoprotein cholesterol (normal values < 130 mg/dL), high density lipoprotein cholesterol (normal values > 39 mg/dL), triglycerides, follicle-stimulating hormone (normal range: 2-12 mUI/L), luteinizing hormone (normal range: 2-12 mUI/L), total testosterone (>12 nmol/L), and prolactin (normal range: 0.62-12.4 ng/mL).

A power analysis was carried out to estimate the number of observations needed to have a reliable chance of detecting the effect sought. There are no formal standards for power ($\pi$); the power of our tests using $\pi = 0.90$ as a standard for adequacy was investigated.[13] The power calculations were carried out using the G*Power 3 statistical power analysis program.[14]