How to diagnose penile vascular disease by color duplex Doppler ultrasound (CDDU) ...

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Introduction

• Atherosclerosis involving the aorto-iliac, internal pudendal, common penile or cavernosal arteries and/or microangiopathy of helicine arteries and/or corporal veno-occlusive dysfunction is the predominant pathophysiology of 60-70% of ED

• Common pathway is endothelial dysfunction and/or corporal venous leakage due to age or denervation-related loss of corporal smooth muscle (CCSM)

• Endothelial dysfunction is most often linked to diabetes mellitus, hypertension, dyslipidaemia and cigarette smoking
Penile DSA (non-pharmacological)

IP  Internal pudendal a.
P   Common penile a.
C   Cavernosal a.
D   Dorsal penile a.
SP  Superficial perineal a.
B   Bulbar a
Arteriographic Findings in 59 patients (118 sides)

<table>
<thead>
<tr>
<th>ARTERY</th>
<th>DISEASE PRESENT</th>
<th>NON-VISUALISED</th>
<th>N PATIENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPA</td>
<td>50</td>
<td>10</td>
<td>60/118</td>
</tr>
<tr>
<td>BULBAR</td>
<td>8</td>
<td>73</td>
<td>81/118</td>
</tr>
<tr>
<td>DORSAL</td>
<td>20</td>
<td>66</td>
<td>86/118</td>
</tr>
<tr>
<td>CA</td>
<td>14</td>
<td>91</td>
<td>105/118</td>
</tr>
</tbody>
</table>

GINESTIE, J.F., ROMIEU, A.: Radiologic Exploration of Impotency  
The Hague, Martinus Nijoff Medical Division, 1978
Introduction

• High-resolution gray-scale imaging in combination with color and pulsed-wave Doppler, following ICI pharmacological challenge, forms the basis of modern penile ultrasound evaluation of ED

• CCDU is not mandatory for evaluating all ED patients but has several advantages and indications

• Differential diagnosis of ED is mandatory in good medical practice [10]
Introduction

- CDDU is an objective and reliable diagnostic method for documenting corporal hemodynamics
- Requires trained personnel, experienced in the technique of vascular ultrasound and in the interpretation of results, and expensive equipment
- CDDU results that are not always reproducible unless a SOP is followed
- Significant intra-patient, inter-operator and inter-site variability of results
Physics of Pulsed Wave Doppler

- Pulse wave machines transmit pulses of ultrasound then switch to receive mode.
- Measure the phase shift between the received and transmitted signal.
- The echo delay time can be converted into distance.
- Therefore, velocity (speed and direction) and distance (depth) information can be obtained.
Physics of Pulsed Wave Doppler

- Pulsed Wave Doppler (PW)
  - Single crystal, phase shift measured, speed, direction & depth

- Color Doppler
  - Speed and direction encoded in color as indicated by the color bar (BART)

- Spectral Doppler
  - Spectrum of flow velocities represented graphically on the Y-axis and time on the X-axis
Indications for CCDU

- Objective diagnosis in patients unresponsive or refractory to oral ED therapy
- Young men with either primary ED or ED following a pelvic fracture particularly an anterior pelvic fracture with diastasis of the pubic symphysis or blunt perineal trauma
- Differentiation of psychogenic from organic ED
- High flow priapism following blunt perineal trauma
- Evaluation of corporal morphology and haemodynamics in men with Peyronie’s disease, corporal fracture or penile tumour as part of planning either medical or surgical intervention
- Medicolegal evaluation of ED
- Patient request for a diagnosis
Equipment

- Informed verbal consent – details of procedure, risk of post injection ache (20%) and prolonged erection (~1 in 500-1000) and patient instructions for detumescence pharmacotherapy
- A quiet, dimly lit room with only the operator
- Audiovisual set-up for audiovisual sexual stimulation (AVSS)
- Trained physician or sonographer
- Color duplex power Doppler U/S with Sono-CT and high-resolution small parts linear array transducer (≥7.4MHz)
- Hard copy video printer and/or HDD image storage or network DICOM storage using dedicated image capture software e.g. KPAX
- ICI supplies
Probe Frequency

- Suitable for most CCDU
- Higher resolution
- Best for plaque morphology
- Limited by narrow range of velocity
Procedure

- Supine position
- ? Role of initial B mode survey scan prior to ICI challenge
- Flaccid or control CDDU prior to ICI challenge is of value only in men with high-flow priapism
- ICI challenge – alprostadil 4-20mcg dependent on patient age and comorbidity (median 10mcg)
- AVSS + self stimulation to achieve marked tumescence only at start of procedure
Procedure

- Overall corporal morphology
  - B-mode image both sagittal and transverse with and without Sono-CT
  - corporal homogeneity
  - tunical and/or septal plaques, corporal fibrosis, echogenicity or calcification
Penoscrotal Junction - Coronal
Left Distal Corpora
Procedure

- **Haemodynamics**
  - Power Doppler mode with 60° angle using sagittal or coronal imaging
  - Serial determination of peak systolic velocity (PSV), end-diastolic velocity (EDV), resistance indices (RI), and the pulsatility, waveform shape and internal diameter of CA
  - At level of peno-scrotal junction and ideally transperineally to assess proximal CA ideally to the level of the trifurcation of the CPA
  - Measure at 5, 10, 15, 20 +/- 30 minutes or until peak erection with reversal of diastolic flow i.e. RI ≥1.0, or a steady state response occurs
  - Print and/or digitally store images for archiving
Penile Anatomy

Corpus cavernosum
Tunica albuginea
Inner circular layer
Outer longitudinal layer
Urethra
Corpus spongiosum

Dorsal nerve
Deep dorsal vein
Dorsal artery
Erectile tissue
Cavernous artery
Emissary vein
Communicating vein

External iliac a.
Hypogastric a.
Anterior trunk
Internal pudendal a.
Obturator a.
Superficial perineal a.
Artery to the bulb
Cavernosal a.
(Deep penile a.)
Urethral a.
Dorsal penile a.
Mechanism of Erection
Penile CCDU - Shaft CA
Penile CCDU- Trans Perineal CA
Penile CCDU-Trans Scrotal CA
Waveform LCA @ Base of Penis
Waveform RCA @ Transperineal
Procedure

- Avoid insonation of CA at a bifurcation or branching to avoid “jet phenomenon” i.e. high PSV due to non-laminar turbulent flow

- Gross asymmetry of PSV between LCA and RCA suggest duplex CA, extensive collateral circulation due to longstanding vascular disease (trans-tunical DA-CA, trans-septal CA-CA perforators)

- Use Power Doppler with increased gain to evaluate microcirculation
  - Non-visulisation of 1st generation branching of helicine arteries is suggestive of microangiography seen in DM, longstanding hypogonadism, scleroderma and other CT diseases
Procedure

• Compare patient’s report of pharmacological rigidity to operator’s assessment and patient current arousal rigidity

• Patient remains until detumescence commences

• Detumescence pharmacotherapy
  – Patient instruction brochure with A/H contact details
  – 120mg pseudoephedrine at 2 and 4 hour post ICI
  – At 5-6 hours, patient attends A&E for serial corporal aspiration and ICI of dilute selective alpha-adrenergic agonist phenylephrine (100-200mcg/ml)
  – Discharge with achievement of sustained minimal tumescence for ≥ 20 minutes
Waveform changes post-ICI challenge

<table>
<thead>
<tr>
<th>Flaccid</th>
<th>Latent</th>
<th>Tumescent</th>
<th>Full</th>
<th>Rigid</th>
<th>Detumescent</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Waveform" /></td>
<td><img src="image2.png" alt="Waveform" /></td>
<td><img src="image3.png" alt="Waveform" /></td>
<td><img src="image4.png" alt="Waveform" /></td>
<td><img src="image5.png" alt="Waveform" /></td>
<td><img src="image6.png" alt="Waveform" /></td>
</tr>
</tbody>
</table>

![Waveform](image7.png)  ![Waveform](image8.png)  ![Waveform](image9.png)  ![Waveform](image10.png)
# Interpretation of CDDU Results

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>PSV</th>
<th>EDV</th>
<th>RI</th>
<th>d_CA</th>
<th>CA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>&gt;30cm/s</td>
<td>&lt;5cm/s</td>
<td>&lt;0.83</td>
<td>≥0.7mm</td>
<td>Pulsatile with good waveform</td>
</tr>
<tr>
<td>Probable AI</td>
<td>25-30cm/s</td>
<td>&lt;5cm/s</td>
<td>≥0.83</td>
<td>≥0.7mm</td>
<td>? Pulsatility ? poor waveform</td>
</tr>
<tr>
<td>AI</td>
<td>&lt;25cm/s</td>
<td>&lt;5cm/s</td>
<td>≥0.83</td>
<td>≥0.7mm</td>
<td>↓Pulsatility poor waveform</td>
</tr>
<tr>
<td>CVOD</td>
<td>&gt;30cm/s</td>
<td>&gt;5cm/s</td>
<td>&lt;0.83</td>
<td>≥0.7mm</td>
<td>Pulsatile with good waveform</td>
</tr>
<tr>
<td>MVED</td>
<td>&gt;30cm/s</td>
<td>&gt;5cm/s</td>
<td>&lt;0.83</td>
<td>≥0.7mm</td>
<td>↓Pulsatility poor waveform</td>
</tr>
</tbody>
</table>
## Normal CA PSV

<table>
<thead>
<tr>
<th>Artery</th>
<th>Minimum</th>
<th>Average</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>(L) CA</td>
<td>30</td>
<td>45.5</td>
<td>88</td>
</tr>
<tr>
<td>(R) CA</td>
<td>31</td>
<td>40.8</td>
<td>80</td>
</tr>
<tr>
<td>(L) CA TRANSPERINEAL</td>
<td>31</td>
<td>60.9</td>
<td>100</td>
</tr>
<tr>
<td>(R) CA TRANSPERINEAL</td>
<td>34</td>
<td>59.1</td>
<td>97</td>
</tr>
</tbody>
</table>
Mean RCA PSV

PSV(cm/sec)

Age (year)

<26 26 - 35 36 - 45 46 - 55 56 - 65 >65
Practical Applications of trans-perineal insonation of proximal CA

- Identify the proximal extent of arterial occlusive disease
- Identify patients with collateral circulation which lead to normal arterial penile shaft PSV’s despite proximal arterial occlusive disease
- Investigate ED secondary to pelvic or perineal trauma
- Plan vascular reconstructive surgery
- Investigate high flow (arterial) priapism
Collateral Vessels

• “In patients with advanced atherosclerotic disease, formation of collaterals within the penile arterial network appears to be important in maintaining flow to the cavernosal arteries” [1]

• “Multiple potential collateral routes were shown, including transverse collaterals at the root of the penis and communications between cavernosal and dorsal penile arteries.” [2]

1. Schwartz AN. Freidenberg D. Harley JD, Radiology 1988
Trans-perineal insonation of proximal CA

- Proximal CAs can be visualised in most patients up to the level of the trifurcation of the CPA by perineal CCDU of the corpora allowing measurement of flow parameters

- 36% of patients with normal shaft CA PSV had abnormally low PSV in the proximal CA

- This suggests the presence of proximal arterial occlusive disease and “normal” shaft PSV due to collateral circulation, CA-CA trans-septal perforators or DA-CA trans-tunical perforators

- Potential exists for a false negative diagnosis of vasculogenic ED in these patients
High Flow Priapism
3/12 post-Gelfoam® embolisation
High Flow Priapism
Mondor’s Disease of Penis

- Superficial thrombophlebitis of the dorsal vein of the penis
Peyronies Disease
Peyronies Disease

Coronal view of proximal penis with calcified plaque arising from the central intercorporal septum and extending superiorly and laterally to involve the dorsal tunica of both corpora

Saggital view of proximal penis with longitudinal calcified plaque involving the dorsal tunica
Conclusions

- High-resolution gray-scale imaging in combination with color and pulsed-wave Doppler, following ICI pharmacological challenge, forms the basis of modern penile ultrasound evaluation of ED

- CCDU is not mandatory in the evaluation of ED but ... has several advantages
Thank You