Penile Duplex Doppler Ultrasound
Reassessing Standards & Strategies for Optimizing Outcomes

John P. Mulhall MD MSc FECSM FACS
Director, Sexual & Reproductive Medicine Program, Urology Service
Memorial Sloan Kettering Cancer Center, NY, USA
Vascular Evaluation of Erection

• Penile-brachial index (PBI)
• NPTR (Rigiscan)
• Office injection test
• Cavernosometry (DIC)
• Cavernosography
• Selective internal pudendal arteriography (SIPA)
• Penile duplex Doppler ultrasound (PDDU)
Introduction: PDDU

• Introduced in 1980’s as means of assessing erectile hemodynamics

• Useful tool in patients with ED – might aid in defining the etiology of ED

• Assesses inflow and outflow

• May serve as a prognostic tool

• Minimally invasive - has replaced cavernosometry and arteriography

• Goal is achievement of complete smooth muscle relaxation

Role of PDDU

• Define erectile hemodynamics

• Assess arterial inflow – occult/future coronary artery disease

• Assess venocclusive function – venous leak as a prognostic factor
Aim of PDDU

The accuracy of PDDU is entirely predicated upon the ability to completely relax the cavernosal smooth muscle.
Truism

PDDU is never falsely normal

(provided the cavernosal arteries are being scanned)
Protocol

• Probe (7.5-15 MHz)

• Vasoactive agents

• Redosing strategy

• Time vs rigidity-based scanning

• Erection reversal (Phenylephrine)

• MAOI
Implications of a False Diagnosis

• Arterial insufficiency patients might be sent for cardiological investigation

• Arterial insufficiency patients may end up getting unnecessary angiography

• Venous leak patients might end up being treated with unnecessary ICI

• Venous leak patients might end up getting unnecessary penile implant
False Diagnosis of CVOD

- **Diagnosis of CVOD**
  - **n=292**

  - **CVOD alone**
    - **n=202**
      - Repeat DUS
        - Normal
          - **n=42**
          - CVOD
            - **n=160**
              - Normal
                - **n=68**
                - CVOD
                  - **n=92**
              - CAI
                - **n=20**
                - CVOD
                  - **n=16**
                - DIC
                  - **n=14**

  - **CVOD + CAI**
    - **n=90**
      - Repeat DUS
        - Normal
          - **n=6**
          - CVOD
            - **n=10**
            - CAI
              - **n=8**
              - CVOD + CAI
                - **n=16**

  - Normal
    - **n=8**
    - CVOD
      - **n=8**
      - DIC
        - **n=10**
        - CAI
          - **n=8**
          - CVOD + CAI
            - **n=16**
Predictors of False Venous Leak Diagnosis

<table>
<thead>
<tr>
<th>Parameter</th>
<th>OR</th>
<th>95% CI</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failed to obtain BQE</td>
<td>9.1</td>
<td>3.6-13.5</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Age &lt;45 years</td>
<td>5.2</td>
<td>2.2-7.0</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>&lt;2 vascular risk factors</td>
<td>3.1</td>
<td>1.6-6.4</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>
## Predictors of False CAI Diagnosis

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Odds Ratio</th>
<th>95% CI</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failure to Obtain BQE</td>
<td>6.2</td>
<td>2.8-11.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Age &lt; 45 years</td>
<td>3.5</td>
<td>1.8-7.1</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Number Vascular Risk Factors</td>
<td>2.2</td>
<td>1.4-4.8</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Unilateral CAI Diagnosis on Initial DUS</td>
<td>1.6</td>
<td>1.3-3.7</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>
Technical Challenges

• Achieving complete cavernosal smooth muscle relaxation

• Maintaining consistency of erectile response during study

• Defining normalcy

• Age reference ranges

• Implications of need for reversal of erection
Complete Smooth Muscle Relaxation

• How can this be defined?

• Negative EDVs

• High level rigidity

• Best quality erection (BQE)

• Need for reversal of erection
Maintaining Erectile rigidity

• It is critical to accurate data acquisition that the erectile rigidity is approximately the same on both sides during scanning of the CA

• Adrenaline surge during scanning may lead to CCSM contraction

• Might lead to diagnosis of uCAI

• UCAI is very uncommon

• uCAI is a predictor of a false diagnosis of CAI
Defining Normalcy

• Generally accepted that the patients with PSV below 25 cm/sec have CAI\(^1\)
  - Sensitivity 100%, specificity 86% (pudendal angiography)\(^2\)

• PSV of 35 cm/sec decreases sensitivity to 76%, increases specificity to 92\%.\(^3\)

• EDV \(>5\) cm/sec accepted as indicator of CVOD.\(^3,4\)

• PDDU not excellent at grading leak – can never account for adrenaline load

• RI has been used with a cut point of less than 0.75 as abnormal\(^4,5\)
  - PSV 90, EDV 10: RI = 0.9

Age Reference Ranges

While attempts have been made to define age reference ranges there is no universally accepted system
Methods

• A PubMed literature search for papers from 2005-2016 was performed

• Search date: August 2016

• Search engine: “penile Doppler ultrasound”, “penile duplex”, and “penile ultrasound”

• Manuscripts published in English language

• Review articles were excluded
Results

109 published studies

55 were considered eligible for analysis

54 ineligible for analysis
Results

Redosing

• 38% reported using a redosing strategy

• 20% have described redosing structure

• 64% mentioned the maximum # or dose of vasoactive agent used
Results

Rigidity Assessment

• 40% mentioned rigidity assessment in their routine

• 55% used a time-based protocol

• Discrepancy in between-side rigidity was mentioned in 4%
Results

Normative Criteria

• Great variability in normative hemodynamic criteria used

• PSV: 13% ≥35cm/s, 42% ≥30cm/s, 24% ≥25cm/s, 22% NR

• EDV: 65% ≤5cm/s, 4% ≤6cm/s, 31% not reported

• Only 4% reported the presence of negative EDV values

• 2% had unilateral cavernosal artery insufficiency reported

• Only 5% mentioned need for reversal
Conclusions

• False diagnosis rates are unacceptably high

• There is a need for standardization of PDDU protocols

• There is a need for reporting guidelines

• There is a need for a critical re-evaluation of the PDDU literature

• Medical society involvement is essential to advancing this