The Case for Pre-Surgical Staging for Morbidly Adherent Placentas (MAP)

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No conflicts of interest to disclose
Objectives

- Discuss role of ultrasound and MRI in antenatal diagnosis of accreta/percreta
- Review the basics of staging for malignancy and relate it to abnormal placentation
- Discuss current literature for placental staging
- Discuss options for establishing a staging classification
Variations on a Theme

Key is loss of decidua
The incidence of placenta accreta is increasing, primarily as a consequence of rising cesarean delivery rates.

- 10 fold increase in the last 50 years
- Some report have increase at 1:500
The majority of patients with accreta have a history of prior cesarean delivery and previa.
IF no previa...then rarely accreta

Table 4. Placenta Previa and Placenta Accreta by Number of Cesarean Deliveries

<table>
<thead>
<tr>
<th>Cesarean Delivery</th>
<th>Previa</th>
<th>Previa*:Accreta⁺</th>
<th>No Previa⁺:Accreta⁺</th>
</tr>
</thead>
<tbody>
<tr>
<td>First⁺</td>
<td>398</td>
<td>13 (3.3)</td>
<td>2 (0.03)</td>
</tr>
<tr>
<td>Second</td>
<td>211</td>
<td>23 (11)</td>
<td>26 (0.2)</td>
</tr>
<tr>
<td>Third</td>
<td>72</td>
<td>29 (40)</td>
<td>7 (0.1)</td>
</tr>
<tr>
<td>Fourth</td>
<td>33</td>
<td>20 (61)</td>
<td>11 (0.8)</td>
</tr>
<tr>
<td>Fifth</td>
<td>6</td>
<td>4 (67)</td>
<td>2 (0.8)</td>
</tr>
<tr>
<td>≥ 6</td>
<td>3</td>
<td>2 (67)</td>
<td>4 (4.7)</td>
</tr>
</tbody>
</table>

* Percentage of accreta in women with placenta previa.
⁺ Increased risk with increasing number of cesarean deliveries; *P < .001.
*⁺ Percentage of accreta in women without placenta previa.
⁺⁺ Primary cesarean.
Clinical Significance

• Placenta accreta may lead to massive obstetric hemorrhage
• Best demonstrated by Miller and colleagues in his study of 62 proven accretas
  • EBL
    • 41 cases >2000 cc (66%)
    • 9 cases >5000 cc (15%)
    • 4 cases >10000 cc (6.5%)
    • 2 cases >20000 cc (3%)

A Pathologist...sees the end result
What actually happened......
Sometimes how it feels....
Again all they see is this...
We have functioned under the idea that...

SURGICAL COMPLEXITY = PATHOLOGY

- i.e. Percreta > Increta > Accreta

- However this is not always representative of the surgical reality.

- From data, estimated blood loss (EBL) or units of blood transfused serve as a surrogate for surgical complexity
<table>
<thead>
<tr>
<th>ICU days after delivery</th>
<th>Volume of transfused blood products (units packed RBCs)</th>
<th>Volume of fluid replacement (l)</th>
<th>DIC</th>
<th>Morbidity</th>
<th>Position of placenta</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.0</td>
<td>3.6</td>
<td>No</td>
<td>None</td>
<td>Accreta + previa</td>
</tr>
<tr>
<td>4</td>
<td>17.0</td>
<td>15.5</td>
<td>No</td>
<td>None</td>
<td>Accreta + previa</td>
</tr>
<tr>
<td>5</td>
<td>18.0</td>
<td>8.0</td>
<td>Yes</td>
<td>Hemorrhagic shock POD 0, hypothermia, hemoperitoneum, laparotomy POD 1</td>
<td>Increta + previa</td>
</tr>
<tr>
<td>5</td>
<td>11.0</td>
<td>0.7</td>
<td>No</td>
<td>Intra-abdominal hemorrhage, laparotomy, bradycardia, cardiac resuscitation</td>
<td>Accreta + previa</td>
</tr>
<tr>
<td>1</td>
<td>4.0</td>
<td>4.6</td>
<td>No</td>
<td>None</td>
<td>Accreta + previa</td>
</tr>
<tr>
<td>2</td>
<td>3.0</td>
<td>3.2</td>
<td>No</td>
<td>None</td>
<td>Accreta + previa</td>
</tr>
<tr>
<td>4</td>
<td>19.0</td>
<td>11.0</td>
<td>Yes</td>
<td>None</td>
<td>Accreta + previa</td>
</tr>
<tr>
<td>0</td>
<td>7.0</td>
<td>3.5</td>
<td>No</td>
<td>None</td>
<td>Accreta + previa</td>
</tr>
<tr>
<td>2</td>
<td>6.0</td>
<td>5.5</td>
<td>No</td>
<td>None</td>
<td>Accreta + previa</td>
</tr>
<tr>
<td>2</td>
<td>6.0</td>
<td>4.0</td>
<td>No</td>
<td>None</td>
<td>Accreta + previa</td>
</tr>
<tr>
<td>2</td>
<td>6.0</td>
<td>6.0</td>
<td>No</td>
<td>None</td>
<td>Accreta + previa</td>
</tr>
<tr>
<td>4</td>
<td>6.0</td>
<td>7.0</td>
<td>No</td>
<td>None</td>
<td>Accreta + previa</td>
</tr>
<tr>
<td>0</td>
<td>0.0</td>
<td>4.5</td>
<td>No</td>
<td>None</td>
<td>Accreta + previa</td>
</tr>
<tr>
<td>1</td>
<td>2.0</td>
<td>3.5</td>
<td>No</td>
<td>None</td>
<td>Accreta + previa</td>
</tr>
<tr>
<td>1</td>
<td>4.0</td>
<td>5.3</td>
<td>No</td>
<td>None</td>
<td>Accreta + previa</td>
</tr>
<tr>
<td>3</td>
<td>7.0</td>
<td>7.0</td>
<td>No</td>
<td>Uterine atony</td>
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<tr>
<td>1</td>
<td>6.0</td>
<td>7.0</td>
<td>No</td>
<td>None</td>
<td>Accreta + previa</td>
</tr>
<tr>
<td>0</td>
<td>2.0</td>
<td>1.8</td>
<td>No</td>
<td>None</td>
<td>Accreta + previa</td>
</tr>
<tr>
<td>0</td>
<td>2.0</td>
<td>2.7</td>
<td>Yes</td>
<td>None</td>
<td>Increta + previa</td>
</tr>
<tr>
<td>1</td>
<td>5.0</td>
<td>2.0</td>
<td>Yes</td>
<td>None</td>
<td>Percreta + previa</td>
</tr>
<tr>
<td>1</td>
<td>3.0</td>
<td>5.0</td>
<td>No</td>
<td>Wound infection</td>
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</tr>
<tr>
<td>1.6</td>
<td>6.3</td>
<td>5.3</td>
<td>No</td>
<td>None</td>
<td>Accreta + previa</td>
</tr>
<tr>
<td>Details for embolization, catheterization, need for blood and blood products, complications, and length of stay</td>
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<tr>
<td>Case</td>
<td>Embolization</td>
<td>Blood loss, mL</td>
<td>Blood transfused, units</td>
<td>Fresh frozen plasma, units</td>
<td>Cryoprecipitate, units</td>
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<td>Yes</td>
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<td>10,000</td>
<td>10</td>
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<td>No</td>
<td>Yes</td>
<td>600</td>
<td>0</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Yes</td>
<td>Yes</td>
<td>600</td>
<td>0</td>
<td>Yes</td>
<td>Yes</td>
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</tbody>
</table>

How do we characterize ....
SURGICAL COMPLEXITY ≠ PATHOLOGY

SURGICAL COMPLEXITY = ?
Prenatal Diagnostic Imaging

• Limited to two types of modalities:
  • Ultrasound/3D Doppler
  • MRI
• The focus of prenatal diagnostic imaging literature has been largely on accuracy of diagnosis for MAP (macro) and increasingly on the degree and/or extent of invasion (micro) in the recent literature.
  • The micro aspect of imaging is very likely done in practice but without a formal framework → This is STAGING
Ultrasound

• First Line!
  • Sensitivity ranges in studies 77-93% across multiple studies
  • Focused on a number of visual markers to assist in diagnosis—
    • Loss of retroplacental hypoechoic zone
    • Multiple placental lakes “swiss cheese” appearance and flow
    • Thinning or disruption of uterine serosa adjacent to bladder wall
    • Mass elevation of tissue beyond serosa
    • Placental-uterine wall interface disruption
Fig. 1. Sensitivity of diagnosis of placenta accreta with ultrasound. CI = confidence interval.
Fig. 2. Specificity of diagnosis of placenta accreta with ultrasound. CI = confidence interval.
Fig. 5. Summary receiver operating characteristic (SROC) curve for ultrasound. The size of the circle is proportional to the weight of the individual study. AUC = 0.9485; SE(AUC) = 0.0148; $Q^* = 0.8884$; SE($Q^*$) = 0.0198.
3D POWER IMAGING..LESS FALSE POSITIVES?

- There have been reports of increasing sensitivity (97%) and specificity (92%) with positive predictive value of 76% using 3D Power Doppler:
  1. Diffuse or focal lacunar flow pattern
  2. Sonolucent vascular lakes with turbulent flow (high velocity PSV > 15 cm/s, low resistance)
  3. Hypervascularity of uterine bladder interface with abnormal vessels linking placenta to bladder
  4. Markedly dilated vessels over peripheral subplacental region

Shih
Normal Placental Vasculariry
Intervillous and cotyledonal circulation parallel to each other, perpendicular to decidual plate

Huge aneurysm, merging intervillous circulation
3D Power Doppler

- Limited data
- Single Institution
- No external validity reported
- Not uniform agreement regarding which factors are most accurate in the diagnosis of placenta accreta.
Ultrasound—In Isolation

- Single Academic Center
  - Previa: Accreta (path proven) matched with Previa: No Accreta by year of delivery
- Ultrasound studies with views of the placenta:
  - De-identified
  - Blinded to clinical history
  - Random sequence.
- Six investigators prospectively interpreted each study for the presence of accreta
  - 3 MFM (>8 years experience…Most were >20 years)
  - 3 Experienced OB radiologists (Fellowship trained in U/S and >10 years experience)

Bowman et al.
Results…

- 229 ultrasound studies from 55 patients with accreta and 56 controls for 1374 independent observations.
- 1205/1374 (87.7% overall, 90% controls, 84.9% cases) studies were given a diagnosis.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Excluding missing/uncertain diagnoses</th>
<th>Missing/uncertain diagnoses assigned as no accreta</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>62.8 (58.7–66.7)</td>
<td>53.3 (49.5–57.1)</td>
</tr>
<tr>
<td>Specificity</td>
<td>86.8 (83.9–89.4)</td>
<td>88.1 (85.4–90.4)</td>
</tr>
<tr>
<td>PPV</td>
<td>82.1 (78.7–85.0)</td>
<td>82.1 (78.8–85.4)</td>
</tr>
<tr>
<td>NPV</td>
<td>70.8 (68.5–73.0)</td>
<td>64.8 (62.9–66.7)</td>
</tr>
<tr>
<td>Accuracy</td>
<td>75.0 (72.5–77.4)</td>
<td>65.8 (63.2–68.3)</td>
</tr>
</tbody>
</table>

Data are % (95% confidence interval).

NPV, negative predictive value; PPV, positive predictive value.

Results..

- Accuracy of diagnosis by patient:
  - Diagnoses for the 56 women with previa only (ie, controls) were correct significantly more often than for the 55 accreta cases
    - 75% vs 60.4%, respectively, P < .0068

- Placenta accreta was associated more with:
  - Placental lacunae* (odds ratio [OR], 1.4; 95% CI, 1.3-1.6)
  - Loss of the retroplacental clear space * (OR, 2.2; 95% CI, 1.6-3.0)
  - Irregular bladder wall (OR, 1.3; 95% CI, 1.0-1.6)
  - Color Doppler abnormalities (OR, 1.3; 95% CI, 1.1-1.4).
Our results show that when images are reviewed by a diverse group of providers, blinded to any clinical history, ultrasound for the prediction of placenta accreta may not be as sensitive or accurate as previously described.

- Validates that ultrasound is a tool but is far from diagnostic.

- History provides a priori assessment…a pretest probability that affects our evaluation
  - likelihood ratios!
How good is Ultrasound…

• Using the pooled sensitivity and specificity of previous studies (83% and 95%, respectively),
  • Likelihood ratio positive is calculated to be 16.6
  • Thus, a patient with a previa and 1 or 2 cesarean deliveries, the pretest probabilities would be 11 and 40%, respectively, and the posttest probabilities would be approximately 65 and 90% for a positive ultrasound result.
  • Conversely, the likelihood ratio negative would be 0.18 with posttest probabilities of approximately 2 and 10% respectively.
• Even with a relatively good test, we cannot completely eliminate the possibility of an accreta.
How good is Ultrasound alone

- If the blinded diagnostic performance characteristics are considered (sensitivity of 53.5% and specificity of 88%), the LHR positive is only 4.5 (compared to 16) and LHR negative only 0.53.
  - Thus for a patient with a previa and 2 prior cesarean deliveries, the posttest probability:
    - Positive ultrasound result would be approximately 65%
    - Negative ultrasound result 20%
Things to consider...

- This is a study of still images...not real time evaluation (no cine clips, 3D power Doppler were used)
- Not reflective of actual practice today
- Clearly history adds bias (or context), but will increase your post-test probability for positive findings. BUT not eliminate risk with a negative study
- False negatives (which was 18.3%) in this case has very grave consequences
Magnetic Resonance Imaging (MRI)
Magnetic Resonance Imaging

- Studies evaluating magnetic resonance imaging for confirmation or exclusion of placenta accreta have yielded conflicting results.
- Markers:
  - Intraplacental T2 dark bands (intraplacental infarcts)
  - Abnormal intraplacental vascularity
  - Heterogenous intraplacental signal intensity
  - Focal interruption of myometrium
  - Uterine bulging
Advantages

- Often used on equivocal cases...not a first line tool
- Adjuvant modality
- Can overcome barriers such as obesity, posterior placental location, angle of insonation issues, etc.
MRI Specificity

Lam G (2002) 0.00 (0.00 - 0.98)
Warshark CR (2006) 1.00 (0.77 - 1.00)
Dwyer BK (2008) 0.65 (0.38 - 0.86)
Masselli G (2008) 1.00 (0.91 - 1.00)
Lim PS (2011) 0.75 (0.19 - 0.99)
Elhawary TM (2013) 0.87 (0.69 - 0.96)

Pooled Specificity = 0.88 (0.81 to 0.94)
Chi-square = 24.25; df = 5 (p = 0.0002)
Inconsistency (I-square) = 79.4%

Fig. 6. Summary receiver operating characteristic (SROC) curve for magnetic resonance imaging. The size of the circle is proportional to the weight of the individual study. 

\[
\text{AUC} = 0.8963; \quad \text{SE(AUC)} = 0.0680; \quad Q^* = 0.8273; \quad SE(Q^*) = 0.0719. \quad \text{AUC} = \text{area under the curve;} \quad \text{SE} = \text{standard error.}
\]
MRI for diagnosis

- As most patients referred for placental evaluation with MR imaging have suspicious findings on ultrasonography, the pretest probability for abnormalities on MR imaging is high.

- For the most part, ultrasound and MRI imaging are complementary, in that if inconclusive findings are found with one technique, the other can be used to clarify the potential abnormality. (Allen et al. 2013)
Imaging—a different approach

- Thorp et al. (1992) first description of using MRI “altered our surgical approach, diminishing blood loss and morbidity”

- Imaging studies used not only for confirmation of diagnosis but for depicting “topography”
  - Term coined by Dr. Palacios-Jaraquemada
  - Characterizes the lesion in relation to soft tissue pelvic tissue

- The framework for staging
## What we do?

<table>
<thead>
<tr>
<th>Question</th>
<th>Responses [n (%)]</th>
<th>Low suspicion for accreta</th>
<th>High suspicion for accreta</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which of the following imaging modalities would you order to further assess the placenta in preparation for the delivery of this patient? (Select all that apply)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>60 (12.2)</td>
<td>33 (6.7)</td>
<td></td>
</tr>
<tr>
<td>Serial 2D ultrasound exams</td>
<td>367 (74.6)</td>
<td>324 (66.1)</td>
<td></td>
</tr>
<tr>
<td>3D ultrasound</td>
<td>67 (13.6)</td>
<td>78 (15.9)</td>
<td></td>
</tr>
<tr>
<td>MRI (+/- contrast)</td>
<td>212 (43.1)</td>
<td>333 (68)</td>
<td></td>
</tr>
<tr>
<td>Cystoscopy</td>
<td>49 (10)</td>
<td>64 (13.1)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Jolley et al. (2011)
Where we are now?

- We use history, ultrasound and +/-MRI to determine diagnosis of MAP
  - Inherent flaws in each modality towards diagnosis
  - Leads to poor resource allocation (both under and over)
  - No coordinated language/nomenclature
- Imaging is informally used at all for “mapping” surgical approach
Why Pre-surgical Staging?
Staging...

• A good staging system must have 3 basic characteristics
  • Valid
  • Reliable
  • Practical

• Staging system must be evidence based and user friendly
  • Based on and updated according to latest available knowledge
    • “Responsive and Adaptive”
History

• In 1928 Federation of Gynecology and Obstetrics (FIGO) formed
  • exploring the possibility of producing uniform statistical information for treatment methods for uterine cervical cancer

• The group of experts recommended that the task could only be accomplished if various institutions could:
  • produce statistical information collected in a consistent manner for analysis and evaluation.

• Stressed the **absolute necessity of a uniform method to describe the extent of the disease**
The evolution continues…

• Findings were reported annually and data was analyzed after 5 or more years.

• In an effort to promote more uniform grouping of cases, the first “Atlas on Cervical Cancer Staging” was published.
  • Contained changes to the wording and definitions for the various stages of cervical cancer and, as such, represented the first recorded changes.
Since its inception in 1938, this classification system has undergone 7 changes!

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 0</td>
<td>Carcinoma in situ, intraepithelial neoplasia Grade III</td>
</tr>
<tr>
<td>Stage I</td>
<td>Lesions ≤2 cm in size, confined to the vulva or perineum, no nodal metastasis</td>
</tr>
<tr>
<td>Ia</td>
<td>Lesions ≤2 cm in size, confined to the vulva or perineum and with stromal invasion ≤1.0 mm³, no nodal metastasis</td>
</tr>
<tr>
<td>Ib</td>
<td>Lesions ≤2 cm in size, confined to the vulva or perineum and with stromal invasion &gt;1.0 mm³, no nodal metastasis</td>
</tr>
<tr>
<td>Stage II</td>
<td>Tumor confined to the vulva and/or perineum; &gt;2 cm in greatest dimension, no nodal metastasis</td>
</tr>
<tr>
<td>Stage III</td>
<td>Tumor of any size with adjacent spread of the lower urethra and/or the vagina, or the anus, and/or unilateral regional lymph node metastasis</td>
</tr>
<tr>
<td>Stage IV</td>
<td>Tumor invades any of the following: upper urethra, bladder mucosa, rectal mucosa, pelvic bone, and/or bilateral regional node metastases</td>
</tr>
<tr>
<td>IVa</td>
<td>Any distant metastasis including pelvic lymph nodes</td>
</tr>
</tbody>
</table>

* The depth of invasion is defined as the measurement of the tumor from the epithelial-stromal junction of the adjacent most superficial dermal papilla to the deepest point of invasion.

However, this is NOT Cancer

- Pathology of the disease is not progressive/aggressive as other cancer
  - Does not systemically metastasize

- With exception of cervical cancer and GTN, staging is based on surgical-pathological findings rather than clinical findings

- Cancer has continued management issues beyond surgery that staging does influence
Main objective of staging

1. Aid the clinician in planning treatment
2. Provide indication of prognosis
3. Contribute to continuing investigation, thus disseminating knowledge
Staging MAP is not a new concept...

• First system introduced by Palacios-Jaraquemada and Bruno et al. (2005) [PJB for short]
  • 300 accretas retrospectively reviewed with ultrasound
    • 252 had MRI evaluation as well (30-33 wks)
      • Placental invasion was classified in levels of depth and area relative to posterior vesical wall
      • Correlated with surgical appearance
PJB Classification cont’d

• Saggital MRI image
  • Anterior placenta invasion divided into 2 sectors by a perpendicular plane posterior bladder wall
    • S1 (Upper bladder wall)
    • S2 (Lower bladder wall)

• Placental invasion by MRI
  • 0– Absence of placental invasion
  • A- Partial myometrial invasion
  • B- Total myometrial invasion
  • C- Invasion that involved the whole myometrium + parametrial involvement (one or both)

• Final degree of invasion & topography determined in OR and compared to MRI
• MRI modified the interpretation of invasion degree in 90 patients (30%), and classified invasion topography in 286 patients (95.33%).

<table>
<thead>
<tr>
<th></th>
<th>AB US</th>
<th>TV US</th>
<th>DP US</th>
<th>US diagnosis</th>
<th>pMRI NF</th>
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</thead>
<tbody>
<tr>
<td>Group 1 ( (n = 38) )</td>
<td>38</td>
<td>0</td>
<td>0</td>
<td>Placenta accreta: 26</td>
<td>Invasion 0: 7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Placenta increta: 12</td>
<td>Invasion B: 11</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Invasion C: 3</td>
</tr>
<tr>
<td>Group 2 ( (n = 134) )</td>
<td>134</td>
<td>43</td>
<td>0</td>
<td>Placenta accreta: 102</td>
<td>Invasion 0: 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Placenta increta: 30</td>
<td>Invasion B: 17</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Invasion C: 3</td>
</tr>
<tr>
<td>Group 3 ( (n = 128) )</td>
<td>128</td>
<td>102</td>
<td>97</td>
<td>Placenta accreta: 88</td>
<td>Invasion B: 40</td>
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<tr>
<td></td>
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<td></td>
<td>Placenta increta: 38</td>
<td>Invasion C: 5</td>
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<td></td>
<td></td>
<td>Placenta percreta: 2</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>300</td>
<td>145</td>
<td>97</td>
<td>300</td>
<td>NF: 90 (30%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>NF: 284 (94.66%)</td>
</tr>
</tbody>
</table>

AB US, abdominal ultrasound; D US: Doppler ultrasound; pMRI, placental magnetic resonance imaging; NF, new findings; TV US, transvaginal ultrasound. 0, no invasion; A, partial invasion; B, total invasion; C, parametrial invasion. Group 1, AB US; group 2, AB US + TV US; group 3, AB US + TV US + Doppler.
Table III. Analysis by localization and outcome (pMRI classification)

<table>
<thead>
<tr>
<th></th>
<th>O</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>136</td>
<td>49</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>UC (%)</td>
<td>136</td>
<td>47</td>
<td>3 (60)</td>
<td></td>
</tr>
<tr>
<td>TAH (%)</td>
<td>0 (0)</td>
<td>2 (4.1)</td>
<td>2 (40)</td>
<td></td>
</tr>
<tr>
<td>TR</td>
<td>0–1 U (0.25 median)</td>
<td>1–3 U (1.79 median)</td>
<td>1–4 U (2.2 median)</td>
<td></td>
</tr>
<tr>
<td>S2</td>
<td>70</td>
<td>23</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>UC (%)</td>
<td>60 (35.7)</td>
<td>12 (52.17)</td>
<td>1 (16.6)</td>
<td></td>
</tr>
<tr>
<td>TAH (%)</td>
<td>10 (14.3)</td>
<td>11 (47.83)</td>
<td>5 (83.4)</td>
<td></td>
</tr>
<tr>
<td>TR</td>
<td>2–5 U (3.2 median)</td>
<td>5–10 U (6.9 median)</td>
<td>3–7 U (5.16 median)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>11 (UC 100%)</td>
<td>206</td>
<td>72</td>
<td>11</td>
</tr>
</tbody>
</table>

TAH, total abdominal hysterectomy; UC, uterine conservation. 0, no invasion; A, partial invasion; B, total invasion; C, parametrial invasion; TR, transfusions.
Changes in conduct secondary to MRI study included:

1. Surgery rescheduling at week 35 (68 cases)
2. Ureteral catheterization (11 cases)
3. Indication of intraoperative blood salvage (43 cases)
4. Presence of specialists (43 cases)
5. Possibility of Pfannenstiel incision (19 cases)
6. Segmental myometrial approach (34 cases)
7. Aortic vascular control (22 cases)
8. Detection of subclinical disseminated intravascular coagulation (21 cases)
9. Posterior pelvic dissection (15 cases)
10. Possibility of uterine conservation (236 cases).
• Makes the case that topography of placental location is linked to vascular supply
  • S1 → receives blood from uterine and upper vesical arteries
  • S2 → anastomatic irrigation and originates from multiple pedicles (deep pelvic vessels)
  • Increased invasion implies need for greater operative procedures

• ➔ “a fact which significantly increases S2’s surgical complexity” and hemorrhage potential
• “Usual to observe discrepancies among ultrasound report, histology and surgical complexity of PAD (aka MAP). Repetition of these differences would imply the usefulness of replacing the morphological classification with a topographic one”

• Specific topographic knowledge of placental invasion (S1 A, B and S2 A) provides the possibility of performing a segmental approach and also of performing a Pfannenstiel incision

• Presurgery localization of B and C invasions (percreta and parametrial invasions) turned out to be vital to plan surgery
  • Timing of surgery
  • Suggest the placement of a urinary catheter in order to prevent possible ureteral injuries during deep pelvic dissection
Further refinement...

- In a more recent paper 2013, Palacios-Jaraquemada et al. added 272 more cases to his pre-existing study.
  - Ultrasound is sufficient if goal is for uterine conservation.
  - But if resection is required, detailed evaluation of the invasiveness and topography of the placenta is highly recommended.

<table>
<thead>
<tr>
<th>Procedure</th>
<th>S1 invasion</th>
<th>S2 invasion</th>
<th>Parametrial invasion</th>
<th>CTVH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgery</td>
<td>OSCS-SAHA</td>
<td>OSCS-TAH</td>
<td>OSCS-TAH</td>
<td>OSCS-SAHA</td>
</tr>
<tr>
<td>Proximal vascular Control</td>
<td>Uterine or anterior iliac artery</td>
<td>Aortic or bilateral common iliac</td>
<td>Aortic or bilateral common iliac</td>
<td>Aortic or bilateral common iliac</td>
</tr>
<tr>
<td>Uterine vascular control</td>
<td>UAE-UAL-compression sutures</td>
<td>IIAE-CHO square suture</td>
<td>IIAE-CHO square and simple suture</td>
<td>Avoid dissection or embolization</td>
</tr>
<tr>
<td>Ureteral catheterization</td>
<td>Not necessary</td>
<td>Recommendable</td>
<td>Mandatory</td>
<td>Recommendable but usually very difficult</td>
</tr>
</tbody>
</table>

S1, Sector 1: uterine body; S2, Sector 2: uterine segment-cervix; CTVH, cervico-trigonal vascular hyperplasia; OSCS, one-step conservative surgery; SAH, subtotal abdominal hysterectomy; TAH, total abdominal hysterectomy; UAE, uterine arterial embolization; UAL, uterine artery ligature; IIAE, iliac internal arterial embolization.
Validation...

• Aitken et al. performed a retrospective review of all patients identified antenatally as having MAP based on ultrasound AND MRI from Jan 2000 to Dec 2014
• Applied the PJB grading system on antenatal images and compared to surgical operative notes and pathology reports to determine its effect on surgical management
  • Surgical and pathology reports were graded for each report and compared to the blinded interpretation of MRI/Ultrasound reports

Aitken et al. (2016)
“We believed that the more specific topographic information conveyed using this system was of greater value in guiding surgical management.”
Ultrasound and MRI are not significantly different in their ability to detect MAP.

Aitken et al. state that MRI is “necessary for the accurate assessment of demarcation and degree of placental invasion.”

MRI to be 97.66% accurate in characterizing the level and topography of invasion.

Lower numbers than what was reported by PJB representative of retrospective nature of the study.
Effect on surgical approach

• Best demonstrated on rates of EBL in lower and higher stage MAP:
  • S2C invasion was 1.7 times more likely EBL>2000 cc or >4 units pRBC compared to S1A to S2B (p=0.08)
  • Truly difficult to prove in a retrospective review but
    • Suggests higher grade allows for preparation for massive blood loss
      • **remember this when we discuss IR procedures
  • Conservative management option on lower stages
How about Ultrasound ability to determine invasion?

• Jauniaux et al. (2016) evaluated ultrasound literature for invasiveness terminology
  • Overall lack of consistent terminology utilized among studies
  • Ultrasound often focuses on MAP overall and does not assess for invasion
    • Contributes to inaccuracy in U/S literature
      • Abnormally adherent vs abnormally invasive (??)
Rac et al. (2014) performed a retrospective review of sonographic variables in patients with histologically confirmed MAP. They determined the significance of each ultrasound finding to estimate invasion based on multiparametric analysis. They also estimated the probability of invasion.
Placenta Accreta Index

- Created by combination of parameters that gave the largest area under the curve was used to generate a predictive equation
- Parameters were given weighted values based on coefficients from the equation
- Scored from 0 to 9
\[ f = -0.1935 - 0.0404 \text{ (grayscale sagittal myometrial thickness \text{[mm]})} \\
- 0.0911 \text{ (if lacuna = 2)} + 1.234 \text{ (if lacuna = 4)} + 0.4195 \text{ (if bridging vessels)} + 1.1332 \text{ (if >1 prior cesarean delivery)} + 0.6772 \text{ (if anterior placentation)}. \]

\[ \text{PAI} = \frac{e^f}{1-e^f} \]
**TABLE 4**

Value of each parameter is added together to generate Placenta Accreta Index score

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥2 cesarean deliveries</td>
<td>3.0</td>
</tr>
<tr>
<td>Lacunae</td>
<td></td>
</tr>
<tr>
<td>Grade 3</td>
<td>3.5</td>
</tr>
<tr>
<td>Grade 2</td>
<td>1.0</td>
</tr>
<tr>
<td>Sagittal smallest myometrial thickness</td>
<td></td>
</tr>
<tr>
<td>≤1 mm</td>
<td>1.0</td>
</tr>
<tr>
<td>&lt;1 but ≥3 mm</td>
<td>0.5</td>
</tr>
<tr>
<td>&gt;3 but ≤5 mm</td>
<td>0.25</td>
</tr>
<tr>
<td>Anterior placenta previa</td>
<td>1.0</td>
</tr>
<tr>
<td>Bridging vessels</td>
<td>0.5</td>
</tr>
</tbody>
</table>

*a* if parameter is not present, then value is 0; *b* Measured in sagittal plane; *c* If any portion of placenta is anterior.


---

**Figure 8**

Receiver operator curves for prediction of placental invasion

- **Placenta accreta index**
  - AUC (95% CI): 0.87 (0.80, 0.95)

- **Number of cesarean deliveries and anterior placental location**
  - AUC (95% CI): 0.80 (0.71, 0.88)

Dashed curve represents prediction of invasion using number of cesarean deliveries and anterior placental location only. Solid curve represents prediction of invasion using Placenta Accreta Index (addition of lacunar spaces, smallest myometrial thickness and bridging vessels). Comparison of 2 curves yield *P* = .03.
<table>
<thead>
<tr>
<th>PAI</th>
<th>n</th>
<th>Probability of invasion, % (95% CI)</th>
<th>Sensitivity (95% CI)</th>
<th>Specificity (95% CI)</th>
<th>PPV (95% CI)</th>
<th>NPV (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;0</td>
<td>1</td>
<td>5 (1–15)</td>
<td>100 (88–100)</td>
<td>19 (10–31)</td>
<td>38 (27–49)</td>
<td>100 (72–100)</td>
</tr>
<tr>
<td>&gt;1</td>
<td>1</td>
<td>10 (4–22)</td>
<td>97 (82–100)</td>
<td>47 (34–61)</td>
<td>47 (34–61)</td>
<td>97 (82–100)</td>
</tr>
<tr>
<td>&gt;2</td>
<td>2</td>
<td>19 (10–32)</td>
<td>93 (77–99)</td>
<td>58 (44–70)</td>
<td>52 (38–66)</td>
<td>94 (81–99)</td>
</tr>
<tr>
<td>&gt;3</td>
<td>4</td>
<td>33 (22–47)</td>
<td>86 (68–96)</td>
<td>68 (54–79)</td>
<td>57 (41–72)</td>
<td>91 (78–97)</td>
</tr>
<tr>
<td>&gt;4</td>
<td>6</td>
<td>51 (36–66)</td>
<td>72 (53–87)</td>
<td>85 (73–93)</td>
<td>70 (51–85)</td>
<td>86 (75–94)</td>
</tr>
<tr>
<td>&gt;5</td>
<td>6</td>
<td>69 (50–83)</td>
<td>52 (33–71)</td>
<td>92 (81–97)</td>
<td>75 (51–91)</td>
<td>79 (68–88)</td>
</tr>
<tr>
<td>&gt;6</td>
<td>2</td>
<td>83 (63–93)</td>
<td>31 (15–51)</td>
<td>100 (94–100)</td>
<td>100 (66–100)</td>
<td>75 (64–84)</td>
</tr>
<tr>
<td>&gt;7</td>
<td>2</td>
<td>91 (73–97)</td>
<td>24 (10–44)</td>
<td>100 (94–100)</td>
<td>100 (59–100)</td>
<td>73 (62–82)</td>
</tr>
<tr>
<td>&gt;8</td>
<td>5</td>
<td>96 (81–99)</td>
<td>17 (6–36)</td>
<td>100 (94–100)</td>
<td>100 (48–100)</td>
<td>71 (60–81)</td>
</tr>
</tbody>
</table>

CI, confidence interval; NPV, negative predictive value; PAI, Placenta Accreta Index; PPV, positive predictive value.

Why we need to consider presurgical staging or scoring?
Main objective of staging

I. Aid the clinician in planning treatment
II. Provide indication of prognosis
III. Contribute to continuing investigation, thus disseminating knowledge
Aid the Clinician in Treatment

- We need to talk the same language
  - Stop looking at the judge…
  - Describe the topography not the pathology
    - “I operated on a bad accreta last night”
    - “Yesterdays case, the placenta was diffuse and fills up the lower uterine segment with bulging into the right parametrium and possible encroachment on the left aspect of the posterior bladder”
    - Might be better if we could say it’s a “Stage IIIR”

The application of pathological definitions to in vivo environment is counterproductive and nonsensical!!
• Aids in regionalizing patient to Centers of Excellence

• Allows for coordinated care of patient among members of a multidisciplinary team

• Allocates appropriate interventions for “higher staged” placentas
Provides Indication of Prognosis

- Suspected severity of MAP can be conveyed
  - Identifies patient who will need planned hysterectomy
    - May aid in delivery timing
    - Mobilizes “C-hyst” teams
    - Reserve surgical specialists (i.e. urology, vascular surgeons)
    - Ureteral catheters? Cell Saver?

- Possible “lesser” staged/scored placenta maybe candidates for conservative management
  - Placenta removal? Focal resection?
  - Pfannenstiel incision vs. midline
Contribute to continuing investigation, thus disseminating knowledge

• RESEARCH!!!
  • Literature in MAP are muddled with inconsistencies
    • Result of a vague terminology?
    • Result of inappropriate lumping of heterogeneous groups?
    • Studies mix accreta outcomes with percreta outcomes
      • Mixing apples with oranges
    • Since accreta are far more prevalent than more invasive are we “diluting” the outcome we are trying to study?
  • Example: IR procedures
<table>
<thead>
<tr>
<th>Author</th>
<th>Total (#Balloons)</th>
<th>Balloons/Emboliz</th>
<th>Comparison Group</th>
<th>Benefit</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cali (2014)</td>
<td>53 (30)</td>
<td>Yes/No</td>
<td>Yes</td>
<td>Yes</td>
<td>• Benefit observed in percretas&lt;br&gt;• No benefit in accreta/increta</td>
</tr>
<tr>
<td>Ballas (2012)</td>
<td>117 (59)</td>
<td>Yes/No</td>
<td>Yes</td>
<td>Yes</td>
<td>• Majority of controls not diagnosed antenatally&lt;br&gt;• Only study to deploy balloons situationally vs routinely</td>
</tr>
<tr>
<td>Angstmann (2010)</td>
<td>26 (8)</td>
<td>Yes/Yes</td>
<td>Yes**</td>
<td>Yes-from embolization</td>
<td>• Patients in both groups received balloons, difference between groups was embolization**</td>
</tr>
<tr>
<td>Mok M (2008)</td>
<td>13</td>
<td>Yes/Yes</td>
<td>No</td>
<td>No</td>
<td>• No comparison group</td>
</tr>
<tr>
<td>Tan (2007)</td>
<td>25 (11)</td>
<td>Yes/Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>• Notes benefit in Blood loss and need for transfusion.&lt;br&gt;• No difference in mean Hgb change</td>
</tr>
<tr>
<td>Shrivastava (2006)</td>
<td>69 (19)</td>
<td>Yes/No</td>
<td>Yes</td>
<td>No</td>
<td>• No difference noted when emergency cases were excluded from control group</td>
</tr>
<tr>
<td>Bodner (2006)</td>
<td>28 (6)</td>
<td>Yes/Yes</td>
<td>Yes</td>
<td>No</td>
<td>• No comparison group</td>
</tr>
<tr>
<td>Shih (2005)</td>
<td>5</td>
<td>Yes/No</td>
<td>No</td>
<td>----</td>
<td>• No comparison group</td>
</tr>
<tr>
<td>Penning (2001)</td>
<td>72 (14)</td>
<td>Yes/No</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Levine (1999)</td>
<td>9 (5)</td>
<td>Yes/No</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>
Contribute to continuing investigation, thus disseminating knowledge

• What if there is benefit from IR procedures but since we group all patients we cannot identify the benefits
  • Implies that hysterectomy has inherent blood loss that cannot be fully minimized
  • What if we compared similar staged/scored MAP with any given intervention
    • i.e. compare apples to apples and oranges to oranges
    • Prospective trials must adopt this concept or risk a study that yields no results (beta error)
So where do we start?
Summary of attempts thus far...

- We have seen in previous staging attempts different modalities AND different origins for derivation of their system
  - **PJB** uses MRI primarily (can use ultrasound but less accurate) and based on single surgeon’s understanding of pelvic blood supply
  - **Placenta Accreta Index** uses ultrasound exclusively and combines a variety sonographic markers and ties them to histopathologic findings
If I could start a system...

- We need smarter people (than me!)
  - FIGO was a consortium
  - Should be a mix—
    - MFM’s with expertise/interest
    - Experienced surgeons of MAP
    - Radiologists with expertise in MRI
    - Surgical subspecialists

- We should incorporate multiple factors to not only estimate the accuracy of diagnosis but the degree of invasion
  - Must have a previa!
  - History of previous uterine surgery
  - Sonographic findings
    - Could use PAI score or a new system incorporating known findings that are weighted based on predictiveness
  - MRI findings
    - MRI’s on any and all patients with at least one prior cesarean
• We should start on a system based on clinical outcomes
  • Using a database of systematically collected data on MAP
  • Stratify patients based on their outcomes in Centers of Excellence
    • Identify characteristics in the diagnosis phase that make each category or stage unique
      • Generate criterion (or scoring) that can be applied prospectively
      • Validate, validate, validate…then Adapt
I. Stage 0–
   a) Placenta previa and No previous cesarean sections
   b) No evidence sonographically of accreta using validated markers
      • Could even use PAI (Rac et al) score less than ≤ 1
   c) No MRI findings (if done, not necessary)

Points

<table>
<thead>
<tr>
<th>Stage 0</th>
<th>0-2 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1</td>
<td>2-4 points</td>
</tr>
<tr>
<td>Stage 2</td>
<td>4-7 points</td>
</tr>
<tr>
<td>Stage 3</td>
<td>7-10 points</td>
</tr>
<tr>
<td>Stage 4</td>
<td>&gt;10 points</td>
</tr>
</tbody>
</table>

• Could have a weighted scoring for each positive finding i.e.
  • Patient “Oh Poop”
  • Placenta previa and 4 previous cesarean [4 pts]
  • Ultrasound markers—(from PAI) Grade 3 lacunae [3 pt] AND <1 mm myometrium at thinnest area [2 pts]
  • MRI (PJB scoring)- S2C with left Parametrial invasion [4 pts] and Posterior bladder wall encroachment [4 pts]

Patient “Oh Poop” Final score of 17 pts
<table>
<thead>
<tr>
<th>Stage 0</th>
<th>Level II</th>
<th>36-37 weeks</th>
<th>Pfannenstiel</th>
<th>Attempt to remove placenta</th>
<th>Unnecessary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1</td>
<td>Level III</td>
<td>34-36 weeks</td>
<td>Surgical discretion</td>
<td>Intraoperative decision (Removal of placenta, focal resection, hyst, etc)</td>
<td>Unnecessary</td>
</tr>
<tr>
<td>Stage 2</td>
<td>Level III</td>
<td>32-33 weeks</td>
<td>Vertical Midline</td>
<td>Hysterectomy</td>
<td>Surgeons discretion</td>
</tr>
<tr>
<td>Stage 3</td>
<td>Centers of Excellence or Level IV</td>
<td>31-33 weeks</td>
<td>Vertical Midline</td>
<td>Hysterectomy</td>
<td>Recommended</td>
</tr>
<tr>
<td>Stage 4</td>
<td>Centers of Excellence or Level IV</td>
<td>31-33 weeks</td>
<td>Vertical Midline</td>
<td>Hysterectomy or in situ conservative management</td>
<td>Recommended</td>
</tr>
</tbody>
</table>
Lastly research...

- Compare the use of IR placed balloon catheters in MAP > stage 2?
- Does Cell saver have a role in MAP > stage 3?
- The use of GIA surgical stapler on uterine incision in MAP?
- Does IR embolization have a role in MAP? Evaluate by stage.
- Does use of a TEG or ROTEM device assist in blood replacement in higher staged MAPs?
- Is there a role of in situ management in > Stage 3 MAP

Etc.... We are all speaking the same language
As scientists responsible for maintaining, modifying, and proposing changes to the existing staging systems, we indeed feel we should shoulder an enormous responsibility to make the appropriate changes timely, wisely, and based on sound scientific data.