Parturition and the Pelvic Floor

ACOG
August 2016

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Directory of Benign Gynecology
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University of MI
University of Michigan Pelvic Floor Research Group

“Improving prevention and treatment of women’s pelvic floor disorders”

Gynecologists, Engineers, Nurses, Urologists, Physical Therapists, Physiologists, Midwives, Radiologists, Psychiatrists, Statisticians, Epidemiologists, Health Services Researchers, Economists, Endocrinologists, Cell Biologists, Veterinarians

Funded by the NIH (ORWH & NICHD)
Conflicts of Interest

- Research funding and consulting from AMS
- Royalties: UpToDate, Springer-Verlag
Objectives

• Review relationship of birth to pelvic organ prolapse.
• Define risks “complex vaginal deliveries” and relationship to levator ani injury.
• Discuss disease prevention and recovery models for birth injuries.
Prevention/Recovery

- Epidemiology
- Disease Model
- Risk vs. Benefit of Intervention
- Natural history of healing
Prevention/Recovery

• Epidemiology
• Disease Model
• Risk vs. Benefit of Intervention
• Natural history of healing
Vaginal Parity and Relative Risk of Prolapse and Urinary Incontinence

Mant J. Br J Obstet Gynecol 1997;104:579
Rortveit G et al. NEJM 2003;348:900
Prolapse is the biggest problem

Vaginal birth is the biggest opportunity.
Injury Rates for Athletics and Vaginal Birth per 1,000 Hours Exposure

- Diagnosis
- Treatment
- Rehab
- Prevention

*2006 NCAA Data & Kearney, Obstet Gynecology 2006;107:144-9
Prevention/Recovery

- Epidemiology
- **Disease Model**
- Risk vs. Benefit of Intervention
- Natural history of healing
Examples:

- Forceps
- Macrosomic infant
- Prolonged second stage
- Occiput posterior
- 4th degree laceration
What happens at some vaginal deliveries that causes Pelvic Organ Prolapse?
Abnormalities of the levator ani in parous women

- 20% of primiparas had defects
- No defects noted in nulliparas
Levator Ani Damage on MRI
Defect after first birth

Obstet Gynecol 2003;101:46

80 primiparous stress incontinent women
80 primiparous continent women
9 months after delivery

- **1 in 10** women had **major** damage to the levator ani muscle
- **90%** involved **pubic origin**
- **Twice as many** levator defects were in the stress incontinent group as the controls
Women with levator ani defects

- They have second stages that are 1 hour longer
- They are 3 times more likely to have been delivered by operative means
- They are four times more likely to have had a sphincter rupture.
- They are twice as likely to have a cystocele
<table>
<thead>
<tr>
<th>Procedure</th>
<th>No LA Defect (n=131)</th>
<th>LA Defect (n=29)</th>
<th>Odds Ratio</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ruptured Sphincter</td>
<td>16.8%</td>
<td>62.1%</td>
<td>8.1</td>
<td>.001</td>
</tr>
<tr>
<td>Forceps</td>
<td>4.6%</td>
<td>41.4%</td>
<td>14.7</td>
<td>.001</td>
</tr>
<tr>
<td>Vacuum</td>
<td>7.6%</td>
<td>6.9%</td>
<td>0.9</td>
<td>.626</td>
</tr>
<tr>
<td>Episiotomy</td>
<td>34.4%</td>
<td>62.1%</td>
<td>3.1</td>
<td>.006</td>
</tr>
<tr>
<td>Epidural</td>
<td>68.7%</td>
<td>65.5%</td>
<td>0.9</td>
<td>.448</td>
</tr>
<tr>
<td>OB Factors</td>
<td>Avulsion (n = 32)</td>
<td>No avulsion (n = 208)</td>
<td>Odds ratio on univariable regression</td>
<td>Odds ratio on multivariable regression</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------------------</td>
<td>-----------------------</td>
<td>--------------------------------------</td>
<td>---------------------------------------</td>
</tr>
<tr>
<td>Epidural</td>
<td>34%</td>
<td>35%</td>
<td>0.96 (CI 0.4–2.1)</td>
<td></td>
</tr>
<tr>
<td>Occipito-posterior</td>
<td>13%</td>
<td>3%</td>
<td>5.05 (CI 1.34–19.1)</td>
<td>3.86 (CI 0.95–15.7)</td>
</tr>
<tr>
<td>Forceps delivery</td>
<td>22%</td>
<td>6%</td>
<td>4.2 (CI 1.53–11.5)</td>
<td>3.83 (CI 1.34–10.94)</td>
</tr>
<tr>
<td>Episiotomy</td>
<td>41%</td>
<td>23%</td>
<td>2.34 (CI 1.08–5.1)</td>
<td></td>
</tr>
<tr>
<td>Vacuum delivery</td>
<td>9%</td>
<td>15%</td>
<td>0.59 (CI 0.17–2.06)</td>
<td></td>
</tr>
<tr>
<td>Birthweight (g)</td>
<td>3561</td>
<td>3460</td>
<td>1.0 (CI 1.0–1.0)</td>
<td></td>
</tr>
<tr>
<td>Length of second stage</td>
<td>94</td>
<td>68</td>
<td>1.01 (CI 1.0–1.01)</td>
<td></td>
</tr>
<tr>
<td>Head circumference (cm)</td>
<td>34.5</td>
<td>34.5</td>
<td>0.99 (CI 0.75–1.30)</td>
<td></td>
</tr>
</tbody>
</table>
Kuo-Cheng Lien, MS
Brian Mooney, MS
John O.L. DeLancey, M.D.
Dee E. Fenner, M.D.
James Ashton-Miller, PhD
Birth-induced injury
(DeLancey Obstet Gynecol, 2003; 101: 46-53)

Missing Muscle

Model Cross-section
Prevention/Recovery

What Caused the LA Defect?

- Muscle tear?
- Nerve injury?
- Compression?
Evaluating Maternal Recovery from Labor & Delivery: Bone and Levator Ani Injuries

Janis Miller, PhD
AJOG 2015;213:188
R21 01-HD049818
P50 HD44406
Study Design

- 68 primiparous women at risk for LA injury
- Investigate women very early post-birth (2-6 wks.)
- Observe the pattern of healing (6-mos) that would point to muscle tear, nerve tear, or nerve/muscle crush injury
Results

- How many were injured?
- What variation in degree?
### MRI Findings That Might Point to Injury Mechanism

<table>
<thead>
<tr>
<th>Early</th>
<th>Late</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Muscle Condition</strong></td>
<td><strong>Edema Pattern</strong></td>
</tr>
<tr>
<td>Host</td>
<td>Focal</td>
</tr>
<tr>
<td><strong>Muscle Bulk</strong></td>
<td><strong>Lost</strong></td>
</tr>
</tbody>
</table>

1) **Muscle tear**

- Early: Disrupted
- Late: Lost
## MRI Findings That Might Point to Injury Mechanism

<table>
<thead>
<tr>
<th></th>
<th>Early</th>
<th>Late</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muscle Condition</td>
<td>Disrupted</td>
<td>Focal</td>
</tr>
<tr>
<td>Muscle tear</td>
<td>Non-disrupted</td>
<td>Diffuse</td>
</tr>
<tr>
<td>Nerve injury</td>
<td></td>
<td>Lost</td>
</tr>
</tbody>
</table>

**Muscle Bulk**
## MRI Findings That Might Point to Injury Mechanism

<table>
<thead>
<tr>
<th></th>
<th>EARLY</th>
<th>LATE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Muscle tear</strong></td>
<td><strong>Muscle Condition</strong></td>
<td><strong>Edema Pattern</strong></td>
</tr>
<tr>
<td></td>
<td>Disrupted</td>
<td>Focal</td>
</tr>
<tr>
<td></td>
<td>Lost</td>
<td></td>
</tr>
<tr>
<td><strong>Nerve injury</strong></td>
<td>Non-disrupted</td>
<td>Diffuse</td>
</tr>
<tr>
<td></td>
<td>Lost</td>
<td></td>
</tr>
<tr>
<td><strong>Compression</strong></td>
<td>Non-disrupted</td>
<td>Adjacent Muscle Involved</td>
</tr>
<tr>
<td></td>
<td>Lost</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EARLY</td>
<td>LATE</td>
</tr>
<tr>
<td>-------------------------</td>
<td>---------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td><strong>Muscle tear</strong></td>
<td>Muscle Condition disrupted</td>
<td>Edema Pattern focal</td>
</tr>
<tr>
<td><strong>Nerve injury</strong></td>
<td>Non-disrupted</td>
<td>Diffuse</td>
</tr>
<tr>
<td><strong>Compression</strong></td>
<td>Non-disrupted</td>
<td>Adjacent Muscle involved</td>
</tr>
</tbody>
</table>
Correlation of LA injury severity with incontinence symptoms at 7-8 month postpartum

<table>
<thead>
<tr>
<th>Test</th>
<th>Correlation Coefficient</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantified standing stress test</td>
<td>.08</td>
<td>.52</td>
</tr>
<tr>
<td>Sandvik questionnaire</td>
<td>.15</td>
<td>.24</td>
</tr>
<tr>
<td>Wei total severity questionnaire</td>
<td>.14</td>
<td>.27</td>
</tr>
<tr>
<td>Leakage index questionnaire</td>
<td>.08</td>
<td>.50</td>
</tr>
</tbody>
</table>
Correlation of LA injury severity 7-8 months postpartum

<table>
<thead>
<tr>
<th></th>
<th>Correlation Coefficient</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MUCP</td>
<td>.06</td>
<td>.69</td>
</tr>
<tr>
<td>Wexner fecal incontinence questionnaire</td>
<td>-.13</td>
<td>.30</td>
</tr>
<tr>
<td>POP – all components</td>
<td>&lt; .15 for all</td>
<td>ns for all</td>
</tr>
<tr>
<td>Pelvic muscle strength on 1-billed speculum</td>
<td>-.43</td>
<td>.001</td>
</tr>
</tbody>
</table>
“Complex Vaginal Births”

- We can predict Levator Ani Injuries
- LA Injuries may not predict immediate symptoms
- SAME risk factors that have been identified for LA injuries also predict symptoms
  - Forceps
  - Older maternal age
  - Sphincter laceration
  - Prolonged second stage
  - Obesity
  - Larger infant
Disease Model

Examples:

- Forceps
- Macrosomic infant
- Prolonged second stage
- Occiput posterior
- 4th degree laceration
Levator ani muscle defects in women with and without prolapse

- Case-Control Study: Group Matching
  - 151 Cases
  - 134 Controls
- Prolapse at least 1 cm below the hymen
- Group matching for age and race
- Full pelvic floor testing (POP-Q, urodynamics, muscle strength, Ultrasound)
Major Levator Ani Defects:
Case-Control Study of Prolapse

Levator Ani Defects

% Defect

0.0%  10.0%  20.0%  30.0%  40.0%  50.0%  60.0%

Levator Ani Defects

Normal  N=134
Prolapse  N=151
Major Levator Ani Defects:
Case-Control Study of Prolapse

- Normal: N=134, 15.5%
- Prolapse: N=151, 40%
What does a levator injury look like?
Imaging

[Images of medical imaging and anatomical structures with labels U, V, R]
Clinical Take Home

- Shortening the second stage for prolonged compression not necessary
- Slow gradual delivery (as we do) is optimal
- Recognize forceps delivery risk
- Strategies to reduce injury; tissue “softening”: (e.g. pre-stretching perineum) now under development
- “VagiDil” in the future
- C/Section: Would it be right to section 9 women (twice) to prevent a treatable problem later?
- Look for strategies to promote recovery
Disease Prevention

- Stop Exposure (Cesarean Section)
- Alter/Minimize Exposure (No forceps)
- Determine who is at greatest risk
- Who does not recover?
Recovery for Low Risk Women

- Young
- No major medical problems
- No major obstetric complications
- Mostly Uncomplicated Deliveries
  - Low rates of instrumented Delivery
  - Low rates of sphincter injury
Contribution of the second stage of labour to pelvic floor dysfunction: a prospective cohort comparison of nulliparous women

RG Rogers, a LM Leeman, b N Borders, c C Qualls, d AM Fullilove, c D Teaf, e RJ Hall, c E Bedrick, f LL Albers g

- APPLE study
- Childbirth and the pelvic floor
- Midwifery Patients
- 6 month follow up
Patient Population

- 336 vaginal births
  - Mean age 23.9 ± 4.9
  - Operative Delivery 5%
  - Episiotomy 2%
  - Anal Sphincter Lac 5%

- 138 Cesarean prior to Second Stage
  - Mean age 26.6 ± 6.1
<table>
<thead>
<tr>
<th></th>
<th>Vaginal Del</th>
<th>C-Section</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any anal incontinence (Wexner* ≥ 1) (%)</td>
<td>163 (50)</td>
<td>76 (55)</td>
<td>0.26</td>
</tr>
<tr>
<td>Fecal incontinence, positive response on Wexner scale (%)</td>
<td>27 (8)</td>
<td>18 (13)</td>
<td>0.12</td>
</tr>
</tbody>
</table>
## Rates of Urinary Incontinence

<table>
<thead>
<tr>
<th>Urinary incontinence</th>
<th>Vaginal birth</th>
<th>Caesarean delivery</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any urinary incontinence, ISI &gt; 0 (%)</td>
<td>183 (55)%</td>
<td>63 (46)%</td>
<td>0.08</td>
</tr>
<tr>
<td>Moderate/severe ISI scores (%)</td>
<td>30 (9)%</td>
<td>8 (6)%</td>
<td>0.35</td>
</tr>
<tr>
<td>Paper Towel Test wet (%)</td>
<td>56 (17)%</td>
<td>8 (6)%</td>
<td>0.002</td>
</tr>
</tbody>
</table>
### Rates of Prolapse

<table>
<thead>
<tr>
<th>Pelvic organ prolapse</th>
<th>Vaginal birth</th>
<th>Caesarean section</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$n = 336$</td>
<td>$n = 138$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>POPQ Stage prolapse</th>
<th>Vaginal birth</th>
<th>Caesarean section</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>46 (14)</td>
<td>28 (22)</td>
</tr>
<tr>
<td>1</td>
<td>209 (65)</td>
<td>81 (63)</td>
</tr>
<tr>
<td>2</td>
<td>66 (21)</td>
<td>19 (15)</td>
</tr>
</tbody>
</table>

| Ba (mean ± SD)      | −1.9 ± 0.8    | −2.1 ± 0.7        |

*0.03**<0.001
Incontinence QOL Measures

- Anal Incontinence
  - No difference

- Urinary Incontinence
  - No difference
  - Urge > Stress for C/S Group
# QOL for Women with Stage 2+ Prolapse

<table>
<thead>
<tr>
<th></th>
<th>Vaginal</th>
<th>Cesarean</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Women with stage 2 or greater prolapse</strong></td>
<td>$n = 67$</td>
<td>$n = 19$</td>
</tr>
<tr>
<td></td>
<td>21%</td>
<td>15%</td>
</tr>
</tbody>
</table>
| **Pelvic organ prolapse impact** | $3.5 \pm 11.8$ | $1.3 \pm 4.5$ | 0.21
• Most low risk women recover well
• Low rates of Urinary Incontinence, Fecal Incontinence, and Prolapse
• Minimal symptoms
• Cesarean Section is not protective for postpartum symptoms
Recovery for High Risk Women

- Older than 32
- Longer second stages of labor
- Instrumented Delivery
  - Forceps
  - Vacuum
- Anal sphincter injury
- Episiotomy
- Symptoms did not predict LA injuries
- Injuries associated with posterior wall descent and decreased pelvic muscle strength
Prevention/Recovery

- Epidemiology
- Disease Model
- Risk vs. Benefit of Intervention
- Natural history of healing for high risk women
The POPI Study
Predicting Optimal Postpartum Recovery from Injury

FUNDED BY PRIVATE DONOR
Aims

• Determine what “normal” recovery looks like for High Risk Women
• Compare pelvic floor recovery in high risk women to cesarean delivery controls
  – Function
  – Symptoms
• Examine the utility of early postpartum screening for injury
  – Clinical markers of injury
Inclusion Criteria

• Vaginal Birth Cohort
  – Primiparous
  – High-risk based on known risk factor

• Cesarean Cohort
  – 1st or 2nd cesarean delivery
  – No second stage
The Trajectory of Recovery in Women at High Risk for Birth Injury

- Analysis
  - Descriptive
    - What does recovery look like?
  - Comparative
    - How does recovery differ between High Risk women and cesarean controls
Preliminary Results

- 96 women
  - 76% High-risk Vaginal Births
  - 24% Cesarean Controls

- Number of women at each time point variable due to ongoing data collection

- Demographics similar except
  - Cesarean group slightly older with lower gestational age at delivery
Levator Strength

<table>
<thead>
<tr>
<th></th>
<th>Force (N)</th>
<th>2 week</th>
<th>6 week</th>
<th>6 month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vaginal</td>
<td></td>
<td>1.1</td>
<td>1.9</td>
<td>2.4</td>
</tr>
<tr>
<td>C/S</td>
<td>N/A</td>
<td></td>
<td></td>
<td>3.4</td>
</tr>
</tbody>
</table>

- **P≤.07**
- **P≤.05**
Ultrasound Visualization of Bladder Lift

Percentage

Baseline 6 week 6 month

Vaginal Delivery C/S Delivery

P ≤ 0.05
Measures of Pelvic Floor Appearance
Anterior Wall Position (Ba)

<table>
<thead>
<tr>
<th>Time</th>
<th>Vaginal Delivery</th>
<th>C/S Delivery</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 week</td>
<td>-1.62</td>
<td>N/A</td>
</tr>
<tr>
<td>6 week</td>
<td>-1.59</td>
<td>-2.71</td>
</tr>
<tr>
<td>6 month</td>
<td>-1.76</td>
<td>-2.4</td>
</tr>
</tbody>
</table>

P ≤ 0.05
Posterior Wall Position (Bp)

Cm Above Hymen

<table>
<thead>
<tr>
<th></th>
<th>2 week</th>
<th>6 week</th>
<th>6 month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vaginal Delivery</td>
<td>-2.2</td>
<td>-2.0</td>
<td>-2.1</td>
</tr>
<tr>
<td>C/S Delivery</td>
<td>N/A</td>
<td>-2.8</td>
<td>-2.7</td>
</tr>
</tbody>
</table>

P ≤ .05

P ≤ .07
Length of GH

\[ P \leq 0.05 \text{ – all time points} \]

<table>
<thead>
<tr>
<th>Time Point</th>
<th>Vaginal Delivery</th>
<th>C/S Delivery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>3.65</td>
<td>2.09</td>
</tr>
<tr>
<td>6 week</td>
<td>3.23</td>
<td>2.29</td>
</tr>
<tr>
<td>6 month</td>
<td>2.91</td>
<td>2.25</td>
</tr>
</tbody>
</table>
Levator Injury
Injury Rate

- High-risk Vaginal Birth injury rate 33%
  - Major Levator injuries 8 (19%)
  - Minor Levator Injuries 6 (14%)
  - No Injuries 28 (67%)

- Cesarean Birth
  - No injuries
Measures of Function

- BC Reflex Present
- Anal Wink Present
- Bladder Lift on U/S

Cesarean
No/Minor Injury
Major Injury

P ≤ 0.05
Measures of Strength

- Oxford Score Bilateral (scale)
- Kegel Force (N)
- Resting Tone (N)

**P≤.07**

- Cesarean
- No/Minor Injury
- Major Injury

**P≤.05**
Length of Genital Hiatus with Strain

$P \leq 0.05$

- **Cesarean**
- **No/Minor Injury**
- **Major Injury**

<table>
<thead>
<tr>
<th>Centimeters</th>
<th>G H Strain</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>3.5</td>
<td></td>
</tr>
<tr>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>4.5</td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td></td>
</tr>
</tbody>
</table>
POPQ Measures

Centimeters Above Hymen

\[ P \leq 0.05 \]  \[ P \leq 0.07 \]

[Graph showing comparisons with error bars]

- BA
- BP
- C

Cesarean
No/Minor Injury
Major Injury

P≤.07
Summary of Findings
High-risk Births vs Cesarean Controls

- High risk vaginal births
  - Decreased strength at 6 weeks
  - Larger Genital Hiatus at 6 weeks and 6 months
  - Lower Anterior and Posterior Walls at 6 weeks and 6 months
Signs of Levator Injury

- Lower posterior walls and wider hiatus in women with major injuries
- Trend towards decreased measures of pelvic muscle strength in women with major injuries
- Potential markers of underlying injury
Disease Model

Symptom Threshold

Pelvic Floor Function

FUTURE DIRECTIONS:

PREDICT WHO IS AT RISK BEFORE DELIVERY?

MAXIMIZE RECOVERY
REPAIR OR REPLACE MUSCLE

0 10 20 30 40 50 60 70
A Familiar Scenario

I’m planning a “Natural” birth
I don’t want to be like my mom!
<table>
<thead>
<tr>
<th><strong>VAGINAL BIRTH AFTER CESAREAN</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Height &amp; weight optional; enter them to automatically calculate BMI</td>
<td></td>
</tr>
<tr>
<td>Maternal age</td>
<td>18 years</td>
</tr>
<tr>
<td>Height (range 54-80 in.)</td>
<td></td>
</tr>
<tr>
<td>Weight (range 80-310 lb.)</td>
<td></td>
</tr>
<tr>
<td>Body mass index (BMI, range 15-75)</td>
<td>25 kg/m²</td>
</tr>
<tr>
<td>African-American?</td>
<td>no</td>
</tr>
<tr>
<td>Hispanic?</td>
<td>no</td>
</tr>
<tr>
<td>Any previous vaginal delivery?</td>
<td>no</td>
</tr>
<tr>
<td>Any vaginal delivery since last cesarean?</td>
<td>no</td>
</tr>
<tr>
<td>Indication for prior cesarean of arrest of dilation or descent?</td>
<td>no</td>
</tr>
</tbody>
</table>

[Calculate]
Predicted chance of vaginal birth after cesarean: 71.8%

95% confidence interval: [69.4%, 74.1%]
### 6 WEEKS POST-PARTUM

<table>
<thead>
<tr>
<th>AGE</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI</td>
<td></td>
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<tr>
<td>2ND STAGE</td>
<td></td>
</tr>
<tr>
<td>FORCEPS</td>
<td></td>
</tr>
<tr>
<td>KEGEL</td>
<td></td>
</tr>
<tr>
<td>GH</td>
<td></td>
</tr>
<tr>
<td>BLADDER LIFT</td>
<td></td>
</tr>
</tbody>
</table>

### RISK

| LEVATOR INJURY | 79% |