Assessing cost-effectiveness of new obstetrical practices with decision analysis
Objectives

• To appreciate the role of decision analysis modeling in assessing cost and effect
• To understand and critically evaluate the components required to create a decision analysis model
• To review the cost-effectiveness of several new screening, diagnostic and treatments changes in obstetrical care
WHY DOES COST-EFFECTIVENESS MATTER?
United States: health care costs

National health care expenditures (% GDP)

Year
1960's
1970's
1980's
1990's
2000's

Percentage of GDP
0
4
8
12
16

2005
2006
2007
China: health care costs

Per capita total expenditure on health at average exchange rate (in US$)
How to assess cost-effectiveness

• Prospective Randomized Controlled Trials
• Prospective Cohort Studies
• Retrospective Cohort Reviews
• Case Series
• Decision Analysis
What is decision analysis?

Using existing evidence to create a model that evaluates the consequences of a particular decision.
Why decision analysis?

- **Time**
  - Faster than traditional study techniques
- **Expense**
  - Minimal costs (computers, software and access to prior research)
- **Flexibility**
  - Can evaluate new screening/diagnostic/treatment modalities as soon as data is released on their utility
- **Expansive**
  - Able to “study” an entire population
- **Ethical**
  - No direct patient risk
Building a decision analysis model to evaluate cost-effectiveness
Model components

1. Decision
2. Consequence(s) (intended & unintended)
3. Probability of consequence(s)
4. Cost of decision
5. Cost of consequence(s)
6. Effect (quality of life)
Decision

• Represents the clinical question
• Usually includes a null hypothesis (i.e. no screening/diagnosis/treatment)
• Can involve a single strategy choice or multiple different strategies
Data
Consequences, probabilities, costs and effect

- Comprehensive search for point estimates and ranges (i.e. PUBMED + bibliography)
  - Meta analyses
  - Randomized controlled trials
  - Cohort studies
  - Case controls
  - Expert opinions
An example

New Haven to Baltimore

GW Bridge
- No traffic: P=0.2, C=$40 / E=1
- Traffic: P=0.8, C=$50 / E=0.6

Tappan Zee Bridge
- No traffic: P=0.6, C=$55 / E=0.5
- Traffic: P=0.4, C=$45 / E=0.9
An example

GW Costs = 0.2*40 + 0.8*50 = 48

Tappan Zee Costs = 0.6*45 + 0.4*55 = 49

GW Effects = 0.2*1 + 0.8*0.6 = 0.68

Tappan Zee Effects = 0.6*0.9+0.4*0.5 = 0.74
Analysis

- Excel
- Tree Age Pro
- Decision Tree Suite
Estimating costs

• All costs must be adjusted to one currency and year
• Economic research has demonstrated that society values current costs more than future costs
• Costs are discounted by 3% per year with a range of 1-5%

\[
\sum_{t=0}^{N} \frac{\text{Cost}_t}{(1 + 0.03)^t}
\]
Estimating effect

• Utilities are numeric values assigned to quality of life (health and disease)
  - Healthy = 1, death = 0
  - Teng TO, Wallace A. One thousand health-related quality-of-life outcomes. Med Care 2000; 38: 583-637

• Utilities are summed over a lifetime to obtain quality-adjusted life years (QALYs)
  - (Health utility X Time in healthy states) + (Disease utility X Time in disease state) = QALY
  - Markov modeling allows movement in and out of multiple disease states
Results

• Total cost of each strategy
• Total effect (quality adjusted life years) associated with each strategy
• Frequency of a particular consequence
• Incremental cost-effectiveness ratio (ICER) between strategies
Calculating cost-effectiveness

$\Delta C / \Delta E = \text{ICER}$

- Incremental resources required
- Incremental effects gained
- Incremental cost-effectiveness ratio
An example

<table>
<thead>
<tr>
<th></th>
<th>GW Costs = 48</th>
<th>Tappan Zee Costs = 49</th>
<th>GW Effects = 0.68</th>
<th>Tappan Zee Effects = 0.74</th>
</tr>
</thead>
</table>

\[
\Delta C = 49 - 48 = 1
\]

\[
\Delta E = 0.74 - 0.68 = 0.06
\]

\[
\text{ICER} = 1 / 0.06 = 16.67
\]

Taking the Tappan Zee instead of the GW Bridge costs $16.67 per unit of happiness gained.
Establishing the cost-effective threshold

- Historically, ICER <$50,000/QALY was considered cost-effective.
- More recently, the willingness-to-pay or cost-effective threshold has increased to $100,000/QALY depending on clinical situation, location and population.
Sensitivity analysis

- Confidence Intervals
- One way
- Two way
- Monte Carlo Simulations
Assessing the cost-effectiveness of recent advances in obstetrics

1. Universal cervical length ultrasound to screen for preterm birth

2. IADPSG guidelines to diagnose gestational diabetes

3. Prenatal repair for fetuses with myelomeningoceles
Universal cervical-length screening to prevent preterm birth: a cost-effectiveness analysis

E. F. WERNER, C. S. HAN, C. M. PETTKER, C. S. BUHIMSCHI, J. A. COPEL, E. F. FUNAI and S. F. THUNG

Department of Obstetrics, Gynecology & Reproductive Sciences, Section of Maternal Fetal Medicine, Yale University School of Medicine, New Haven, CT, USA
Background

- Only 10% of early spontaneous preterm births occur in women with risk factors (multiple gestation, history of preterm birth or history of cervical surgery)\(^1\)
- Preterm birth results in significant short and long term morbidity, particularly at earlier gestational ages
- Cervical length has repeatedly been shown to be inversely proportional to the risk of preterm birth regardless of other maternal risk factors\(^2-4\)
### Background

<table>
<thead>
<tr>
<th></th>
<th>Fonseca</th>
<th>Hassan</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Timing of ultrasound</strong></td>
<td>20-25 weeks</td>
<td>19-23+6/7 weeks</td>
</tr>
<tr>
<td><strong>Multiple gestations</strong></td>
<td>Included</td>
<td>Excluded</td>
</tr>
<tr>
<td><strong>Critical cervical length</strong></td>
<td>&lt;1.5 cm</td>
<td>1-2 cm</td>
</tr>
<tr>
<td><strong>Timing of treatment</strong></td>
<td>24-33+6/7 weeks</td>
<td>20-36+6/7 weeks</td>
</tr>
<tr>
<td><strong>Progesterone type</strong></td>
<td>200mg capsule</td>
<td>90 mg gel</td>
</tr>
<tr>
<td><strong>Number randomized</strong></td>
<td>250</td>
<td>458</td>
</tr>
<tr>
<td><strong>Primary outcome</strong></td>
<td>Significant decrease in deliveries &lt;34 weeks</td>
<td>Significant decrease in deliveries &lt;33 weeks</td>
</tr>
</tbody>
</table>

**Greater than 40% reduction in preterm birth**
Objective

- To determine if universal cervical length screening with progesterone if needed is cost-effective in the US population
- To calculate the number of preterm births prevented using this strategy
- To identify threshold probabilities and costs that make universal cervical length screening cost-effective or ineffective
Decision

- Cervical length screening between 18 and 24 weeks
  - Current method: no screening
  - Alternative method: universal screening

Singletons in women with no prior preterm births

- No Screening
- Screening
Consequences

Cervical length at time of screening

- Screening ultrasound
  - Cervical length >2.5cm
  - Cervical length 1.5cm-2.5cm
  - Cervical length ≤1.5cm

<table>
<thead>
<tr>
<th>Variable</th>
<th>Base</th>
<th>Range</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prevalence of cervical length ≤1.5 cm</td>
<td>1.7%</td>
<td>0.9- 1.9%</td>
<td>1,8,9</td>
</tr>
<tr>
<td>Prevalence of cervical length 1.5-2.5cm</td>
<td>8.3%</td>
<td>7.9- 8.7%</td>
<td>1</td>
</tr>
<tr>
<td>Prevalence of cervical length &gt;2.5 cm</td>
<td>90%</td>
<td>89.4-91.2%</td>
<td>1</td>
</tr>
</tbody>
</table>
Consequences

Intervention (vaginal progesterone 200mg qhs)

- Cervical length ≤1.5cm
  - Progesterone
  - No progesterone

<table>
<thead>
<tr>
<th>Variable</th>
<th>Base</th>
<th>Range</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adherence to progesterone therapy</td>
<td>92.8%</td>
<td>86-97%</td>
<td>1</td>
</tr>
</tbody>
</table>
Consequences

Timing of delivery

- Cervical length ≤1.5cm on Prometrium
- Delivery ≥34 weeks
  - ≥37 weeks
  - 34-37 weeks
  - 28-34 weeks
  - <28 weeks
- Delivery <34 weeks

### Table

<table>
<thead>
<tr>
<th>Variable</th>
<th>Base</th>
<th>Range</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delivery &lt;34 weeks if cervical length ≤1.5 cm</td>
<td>34.1%</td>
<td>9.7-58.7%</td>
<td>1, 2</td>
</tr>
<tr>
<td>Delivery &lt;34 weeks if cervical length 1.5-2.5cm</td>
<td>5.1%</td>
<td>4.2-14%</td>
<td>1, 3</td>
</tr>
<tr>
<td>Delivery &lt;34 weeks if cervical length &gt;2.5 cm</td>
<td>1.2%</td>
<td>1.1-3%</td>
<td>1, 4</td>
</tr>
</tbody>
</table>
Consequences

Neonatal results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Base</th>
<th>Range</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability of severe disability: &lt;28 weeks</td>
<td>10.6%</td>
<td>9.1-17.1%</td>
<td>5</td>
</tr>
<tr>
<td>&gt;28 weeks, &lt;34 weeks</td>
<td>5%</td>
<td>3.3-9.7%</td>
<td></td>
</tr>
<tr>
<td>&gt;34 weeks, &lt;37 weeks</td>
<td>2.4%</td>
<td>2.1-2.6%</td>
<td></td>
</tr>
<tr>
<td>≥37 weeks</td>
<td>1.7%</td>
<td>1.6-1.7%</td>
<td></td>
</tr>
<tr>
<td>Probability of death: &lt;28 weeks</td>
<td>17.9%</td>
<td>8-49.3%</td>
<td>6</td>
</tr>
<tr>
<td>&gt;28 weeks, &lt;34 weeks</td>
<td>0.9%</td>
<td>0.2-8.6%</td>
<td></td>
</tr>
<tr>
<td>&gt;34 weeks, &lt;37 weeks</td>
<td>0.2%</td>
<td>0.1-0.4%</td>
<td></td>
</tr>
<tr>
<td>≥37 weeks</td>
<td>0.07%</td>
<td>0.05-0.09%</td>
<td></td>
</tr>
</tbody>
</table>
Outcomes

• Costs
  • Screening ultrasound
  • Screening consequences
    – Intended: progesterone
    – Unintended: additional ultrasounds, hospitalizations, medications
• Delivery
  – Neonatal care
  – Maternal care
• Long term care
• Effects (healthy, disabled, dead)
• Quality Adjusted Life Years
Putting it all together
## Results

### Table 3: Summary of results (per 100,000 women)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Standard</th>
<th>Screening</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neonatal deaths</td>
<td>170</td>
<td>159</td>
</tr>
<tr>
<td>Severe neurologic deficits</td>
<td>1827</td>
<td>1816</td>
</tr>
<tr>
<td>Neurologic deficit/death averted</td>
<td>-</td>
<td>22</td>
</tr>
<tr>
<td>Births before 34 weeks</td>
<td>2106</td>
<td>1858</td>
</tr>
<tr>
<td>Births before 34 weeks averted</td>
<td></td>
<td>248</td>
</tr>
<tr>
<td>Total QALY</td>
<td>2,954,795</td>
<td>2,955,218</td>
</tr>
<tr>
<td>Marginal QALY gained</td>
<td>-</td>
<td>423</td>
</tr>
<tr>
<td>Total cost (2010 $)</td>
<td>1,314,520,247</td>
<td>1,302,400,300</td>
</tr>
<tr>
<td>Marginal cost (savings in 2010 $)</td>
<td>-</td>
<td>(12,119,947)</td>
</tr>
<tr>
<td>Marginal cost/QALY gained</td>
<td>-</td>
<td>(28,652)</td>
</tr>
</tbody>
</table>
Thresholds based on the one-way sensitivity analysis

- If a transvaginal ultrasound costs more than $187, screening is cost-effective but not cost saving.
- If vaginal progesterone decreases deliveries <34 weeks by <20%, screening is cost-effective but not cost saving.
Monte Carlo Simulation

\[ \Delta \text{Cost} \]

\[ \Delta \text{Effect} \]

- Cost Ineffective
- Cost-Effective

Cost-Savings

Slope = amount willing to pay for each additional QALY
Monte Carlo Scatterplot

Incremental Cost-Effectiveness Scatterplot for Universal Cervical Length Screening vs. No Screening

- Cost saving in 66% of simulations
- Cost-effective in 99.7% of simulations
Conclusions

- If vaginal progesterone decreases the risk of birth < 34 weeks then routine cervical length screening is cost-effective and often cost saving.
- The benefits of vaginal progesterone in women with shortened cervical lengths have now been demonstrated in two RCTs.
- Transvaginal cervical length screening ultrasounds should be considered in all women.
Screening for Gestational Diabetes Mellitus: Are the Criteria Proposed by the International Association of Diabetes and Pregnancy Study Groups Cost-Effective?

Erika F. Werner, MD, MS
Christian M. Pettker, MD
Lisa Zuckerwise, MD
Michael Reel, MD, MBA
Edmund F. Funai, MD
Janice Henderson, MD
Stephen F. Thung, MD

OBJECTIVE—The International Association of Diabetes and Pregnancy Study Group (IADPSG) recently recommended new criteria for diagnosing gestational diabetes mellitus (GDM). This study was undertaken to determine whether adopting the IADPSG criteria would be cost-effective, compared with the current standard of care.

The current screening criteria for GDM were initially chosen to identify patients at risk for developing diabetes after pregnancy and therefore identify a population that has a subsequent 50% risk (1). However, the current application of screening during pregnancy is principally used to identify pregnant women at risk for adverse perinatal outcomes. Some
Background

- Gestational diabetes has been associated with many pregnancy complications.
- The Hyperglycemia and Adverse Pregnancy (HAPO) group identified new screening values that better identify pregnancies at risk for perinatal complications due to hyperglycemia.
- These new screening values were endorsed by the IADPSG but have not been adopted in many places.
- In the U.S. 16% of pregnant women would be diagnosed with gestational diabetes by the IADPSG guidelines (compared to 5.4% currently).
Objective

• To compare the IADPSG guidelines to the current diagnostic guidelines for gestational diabetes
• To compare both diagnostic strategies to a no screening strategy
• To identify threshold probabilities and costs that would make the IADPSG cost effective or cost ineffective
Decision

- Gestational diabetes mellitus (GDM) diagnosis

  - Pregnant women with no history of hyperglycemia
    - No screening
    - ACOG recommended diagnosis strategy
    - IADPSG recommended diagnosis strategy
Current ACOG Recommendation

50-gram 1 hour GTT at 24-28 weeks

≥7.2-7.8 mmol/l (130-140 mg/dl)

100-g 3 hour GTT

Two of the following: fasting ≥5.2 mmol/l (95 mg/dl),
1 hour ≥ 10 mmol/l (180 mg/dl),
2 hour ≥ 8.6 mmol/l (155 mg/dl)
or 3 hour ≥ 7.8 mmol/l (140 mg/dl)

Overt DM or GDM

All others

All others

Insulin sensitive

Insulin sensitive
IADPSG Recommendations

- **Fasting plasma glucose at first prenatal visit**
  - ≥7.0 mmol/l (126 mg/dl) **Overt DM**
  - ≥5.1 mmol/l (92 mg/dl) **GDM**
  - <5.1 mmol/l (92 mg/dl)

- **75-gram 2 hour GTT at 24-28 weeks**
  - Fasting ≥7.0 mmol/l (126 mg/dl) **Overt DM**
  - Fasting ≥5.1 mmol/l (92 mg/dl) 1 hour ≥ 10 mmol/l (180 mg/dl) 2 hour ≥ 8.5 mmol/l (153 mg/dl) **GDM**
  - All others **Insulin sensitive**
## Examples of included consequences

<table>
<thead>
<tr>
<th>Variable</th>
<th>Base-case</th>
<th>Range</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk of preeclampsia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With euglycemia</td>
<td>4.8%</td>
<td>1.4-11.4%</td>
<td>(20)</td>
</tr>
<tr>
<td>With iGDM</td>
<td>5.8%</td>
<td>4.8-12%</td>
<td>(20), (21)</td>
</tr>
<tr>
<td>With cGDM</td>
<td>8.9%</td>
<td>4.8-20.4%</td>
<td>(22), (23)</td>
</tr>
<tr>
<td>With DM</td>
<td>20.4%</td>
<td>8.9-40%</td>
<td>(22)</td>
</tr>
<tr>
<td>Relative risk reduction of preeclampsia with glucose control</td>
<td>0.65</td>
<td>0.44-0.88</td>
<td>(24)</td>
</tr>
<tr>
<td>Risk of shoulder dystocia (SD)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With euglycemia</td>
<td>1.3%</td>
<td>0.1-3.4%</td>
<td>(20)</td>
</tr>
<tr>
<td>With iGDM</td>
<td>1.5%</td>
<td>1.3-2.5%</td>
<td>(20), (21)</td>
</tr>
<tr>
<td>With cGDM</td>
<td>2.7%</td>
<td>1.4-4%</td>
<td>(25), (23)</td>
</tr>
<tr>
<td>With DM</td>
<td>5%</td>
<td>2.5-10%</td>
<td>(26)</td>
</tr>
<tr>
<td>Relative risk reduction of SD with glucose control</td>
<td>0.4</td>
<td>0.21-0.75</td>
<td>(25)</td>
</tr>
</tbody>
</table>
# Results (per 100,000 women)

<table>
<thead>
<tr>
<th>Variable</th>
<th>No Screening</th>
<th>ACOG</th>
<th>IADPSG</th>
<th>Δ ACOG and IADPSG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cases of GDM diagnosed</td>
<td>0</td>
<td>5,020</td>
<td>17,800</td>
<td>12,780</td>
</tr>
<tr>
<td>Future DM cases prevented with intervention</td>
<td>0</td>
<td>446</td>
<td>1,134</td>
<td>688</td>
</tr>
<tr>
<td>Shoulder dystocia</td>
<td>1,051</td>
<td>995</td>
<td>910</td>
<td>85</td>
</tr>
<tr>
<td>Cases of preeclampsia</td>
<td>5,292</td>
<td>5,074</td>
<td>4,812</td>
<td>262</td>
</tr>
<tr>
<td>Total QALY</td>
<td>5,563,323</td>
<td>5,565,646</td>
<td>5,571,824</td>
<td>6,178</td>
</tr>
<tr>
<td>Total cost (2011 $)</td>
<td>831,622,028</td>
<td>870,390,167</td>
<td>996,023,993</td>
<td>125,633,826</td>
</tr>
<tr>
<td>Marginal cost/QALY gained*</td>
<td>-</td>
<td>16,689</td>
<td>20,336</td>
<td>-</td>
</tr>
</tbody>
</table>

* Strategy 2 is compared to strategy 1 and strategy 3 compared to strategy 2
## Limiting long term benefit

Assuming no long term reduction in progression to diabetes mellitus.....

<table>
<thead>
<tr>
<th>Variable</th>
<th>No Screening</th>
<th>ACOG</th>
<th>IADPSG</th>
<th>Δ ACOG and IADPSG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total QALY</td>
<td>5,563,323</td>
<td>5,563,340</td>
<td>5,563,367</td>
<td></td>
</tr>
<tr>
<td>Total cost (2011 $)</td>
<td>831,622,028</td>
<td>840,855,046</td>
<td>856,121,038</td>
<td>15,265,992</td>
</tr>
<tr>
<td>Marginal cost/QALY gained*</td>
<td>-</td>
<td></td>
<td>565,407</td>
<td>-</td>
</tr>
</tbody>
</table>
Conclusions

• IADPSG guidelines are associated with significant perinatal benefits
• Those benefits come at a large cost to the health care system
• GDM diagnosis must be associated with interventions that prevent future overt DM if the IADPSG guidelines are to be cost-effective to society
Evaluating the cost-effectiveness of prenatal surgery for myelomeningocele: a decision analysis

E. F. WERNER*, C. S. HAN†, I. BURD*, H. S. LIPKIND†, J. A. COPEL†, M. O. BAHTIYAR† and S. F. THUNG‡

*Department of Gynecology & Obstetrics, Johns Hopkins School of Medicine, Baltimore, MD, USA; †Department of Obstetrics, Gynecology & Reproductive Sciences, Yale University School of Medicine, New Haven, CT, USA; ‡Department of Obstetrics and Gynecology, Ohio State University, Columbus, OH, USA

KEYWORDS: cost-effectiveness; in-utero surgery; myelomeningocele; prenatal surgery or repair; spina bifida
Background
Prenatal repair
- ↓ need for shunting
- ↑ motor outcomes
- ↑ preterm deliveries
- ↑ pregnancy complications

The Management of Myelomeningocele Study

The MOMS study did NOT

• Account for costs
• Document the impact on maternal quality of life
• Address future pregnancy complications
Objective

- To determine the cumulative costs and effects of prenatal compared to postnatal myelomeningocele repair
- To calculate the incremental cost-effectiveness (ICER) of prenatal compared to postnatal myelomeningocele repair
- To identify thresholds in which prenatal myelomeningocele repair becomes cost-effective or ceases to be cost-effective
The increased costs and decreased quality of life to the mother and future offspring would cause postnatal myelomeningocele repair to be more cost-effective than prenatal repair.
Pregnancy complicated by fetus with myelomeningocele

- Prenatal surgical repair between 19 and 25 6/7 weeks of gestation
- Postnatal surgical repair within the first month of life
Study Population
Maternal consequences

- Pregnancy complications
  - Pulmonary edema
  - Oligohydramnios
  - Placental abruption
  - Membrane rupture
  - Blood transfusion
- Decreased activity
- Mode of delivery in subsequent pregnancies

<table>
<thead>
<tr>
<th>Complications in current pregnancy</th>
<th>Prenatal Repair</th>
<th>Postnatal Repair</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>88.5% (15-100%)</td>
<td>12.5% (0-82%)</td>
</tr>
<tr>
<td>Disutility in current pregnancy</td>
<td>14 weeks (10-25 weeks)</td>
<td>3 weeks</td>
</tr>
<tr>
<td>Probability of cesarean delivery in future pregnancies</td>
<td>100%</td>
<td>72% (50-100%)</td>
</tr>
</tbody>
</table>

Adzick NS et al., 2011; Landon MB et al., 2006.
<table>
<thead>
<tr>
<th>Frequency of:</th>
<th>Prenatal Repair</th>
<th>Postnatal Repair</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complications due to prematurity</td>
<td>74% (53-95%)</td>
<td>34% (15-64%)</td>
</tr>
<tr>
<td>Perinatal death</td>
<td>2.6% (0-5.2%)</td>
<td>2.6% (0-5.2%)</td>
</tr>
<tr>
<td>Hydrocephalus requiring shunt</td>
<td>40% (30-52%)</td>
<td>82% (64-100%)</td>
</tr>
<tr>
<td>Shunt infection</td>
<td>7.4% (6-8.8%)</td>
<td>7.4% (6-8.8%)</td>
</tr>
<tr>
<td>Spinal cord tethering requiring surgery</td>
<td>8% (1-65%)</td>
<td>1.3% (0-2.5%)</td>
</tr>
<tr>
<td>Chiari malformation requiring surgery</td>
<td>1.3% (0.2%-11.2%)</td>
<td>5% (0-10%)</td>
</tr>
<tr>
<td>Motor function $\geq 2$ levels better than expected based on anatomic lesion</td>
<td>32% (12-64%)</td>
<td>12%</td>
</tr>
<tr>
<td>Motor function $\geq 2$ levels worse than expected based on anatomic lesion</td>
<td>13% (0-28%)</td>
<td>28%</td>
</tr>
<tr>
<td>Independent ambulation at 30 months</td>
<td>42% (24-73%)</td>
<td>21%</td>
</tr>
</tbody>
</table>

Adzick NS et al, 2011.
## Future pregnancy consequences

<table>
<thead>
<tr>
<th></th>
<th>Prenatal repair</th>
<th>Postnatal repair</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Timing of delivery (weeks)</strong></td>
<td>36</td>
<td>39</td>
</tr>
<tr>
<td><strong>Severe neonatal neurologic complication</strong></td>
<td>2.4% (0-10%)</td>
<td>1.7% (0-2.4%)</td>
</tr>
<tr>
<td><strong>Delivery complication</strong></td>
<td>44% (0-50%)</td>
<td>4.9% (0-10%)</td>
</tr>
</tbody>
</table>

Wilson RD et al., 2010; Landon MB et al., 2006; Moster D et al, 2008.
<table>
<thead>
<tr>
<th>Service</th>
<th>Base case</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prenatal myelomeningocele repair</strong></td>
<td>20,583</td>
<td>6,363-75,787</td>
</tr>
<tr>
<td><strong>Postnatal myelomeningocele repair</strong></td>
<td>29,445</td>
<td>5,882-246,927</td>
</tr>
<tr>
<td><strong>Maternal complications</strong></td>
<td>4,109</td>
<td>500-20,000</td>
</tr>
<tr>
<td><strong>Neonatal complications due to prematurity</strong></td>
<td>18,875</td>
<td>1,000-200,000</td>
</tr>
<tr>
<td><strong>Shunt placement</strong></td>
<td>27,618</td>
<td>10,000-100,000</td>
</tr>
<tr>
<td><strong>Shunt infection</strong></td>
<td>53,191</td>
<td>13,422-127,468</td>
</tr>
<tr>
<td><strong>Chiari malformation surgery</strong></td>
<td>6,851</td>
<td>4,623-8,293</td>
</tr>
<tr>
<td><strong>Surgery for tethered cord</strong></td>
<td>33,207</td>
<td>10,000-100,000</td>
</tr>
<tr>
<td><strong>Assist devices for non-ambulatory (per year)</strong></td>
<td>583</td>
<td>0-2,000</td>
</tr>
<tr>
<td><strong>Wound care for non-ambulatory (per year)</strong></td>
<td>1,942</td>
<td>0-4,000</td>
</tr>
<tr>
<td><strong>Vaginal delivery</strong></td>
<td>5,709</td>
<td>4,298-6,544</td>
</tr>
<tr>
<td><strong>Cesarean delivery</strong></td>
<td>8,206</td>
<td>6,940-9,576</td>
</tr>
<tr>
<td><strong>Complication during cesarean delivery</strong></td>
<td>691</td>
<td>334-2,256</td>
</tr>
</tbody>
</table>
### Maternal utilities

<table>
<thead>
<tr>
<th></th>
<th>Prenatal Repair</th>
<th>Postnatal Repair</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utility for current pregnancy</td>
<td>0.87 (0.8-0.99)</td>
<td>0.96 (0.9-0.99)</td>
</tr>
<tr>
<td>Utility in future pregnancies</td>
<td>0.96 (0.95-0.99)</td>
<td>0.98 (0.96-1.00)</td>
</tr>
<tr>
<td>Utility outside of pregnancy</td>
<td>0.99 (0.95-1.00)</td>
<td>0.99 (0.95-1.00)</td>
</tr>
</tbody>
</table>

Adzick NS et al., 2011; Landon MB et al., 2006; Chung A et al., 2001; Caughey AB et al., 2005.
# Myelomeningocele Patient Utilities

<table>
<thead>
<tr>
<th>Level of functional deficit</th>
<th>Utility</th>
<th>Life expectancy (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thoracic</td>
<td>0.45</td>
<td>26</td>
</tr>
<tr>
<td>Lumbar</td>
<td>0.54</td>
<td>39</td>
</tr>
<tr>
<td>Sacral</td>
<td>0.61</td>
<td>53</td>
</tr>
</tbody>
</table>

Adzick NS et al., 2011; Tilford JM et al., 2005; Oakeshott P et al., 2010; Arias E, 2003.
## Subsequent offspring utilities

<table>
<thead>
<tr>
<th></th>
<th>Utility</th>
<th>Life Expectancy (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe neurologic deficit</td>
<td>0.61</td>
<td>78</td>
</tr>
<tr>
<td>Healthy</td>
<td>1.0</td>
<td>78</td>
</tr>
</tbody>
</table>

Wilson RD et al., 2010; Landon MB et al., 2006; Moster D et al., 2008; Teng TO et al., 2000.
Results per 100 prenatal repairs performed

• 42 fewer shunts
• 3 fewer neonates afflicted with shunt infections
• 21 more children who can ambulate independently
• 39 more delivery complications in subsequent pregnancies (dehiscence, rupture, abnormal placentation, cesarean hysterectomy, excessive bleeding or prolonged hospitalization)
• 1 additional child from a subsequent pregnancy with severe neurologic deficits
# Results

## Summary of results (per 100 cases)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Prenatal</th>
<th>Postnatal</th>
<th>Δ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal cost</td>
<td>$3,168,883</td>
<td>$774,027</td>
<td>$2,394,856</td>
</tr>
<tr>
<td>Future pregnancy cost</td>
<td>$816,764</td>
<td>$722,800</td>
<td>$93,964</td>
</tr>
<tr>
<td>Total cost</td>
<td>$8,307,704</td>
<td>$10,374,482</td>
<td>($2,066,778)</td>
</tr>
<tr>
<td>Maternal QALYs</td>
<td>2,643</td>
<td>2,666</td>
<td>(23)</td>
</tr>
<tr>
<td>Future offspring QALYs</td>
<td>2,972</td>
<td>2,981</td>
<td>(9)</td>
</tr>
<tr>
<td>Total QALY</td>
<td>6,879</td>
<td>6,781</td>
<td>97</td>
</tr>
<tr>
<td>ICER</td>
<td>-</td>
<td>-</td>
<td>($21,263/QALY)</td>
</tr>
</tbody>
</table>
One-way sensitivity analysis

Tornado Analysis (ICER)

- Cost of postnatal repair
- Cost of prenatal repair
- Cost of neonatal care
- Cost of shunt placement
- Cost of maternal complications
- Cost of shunt infection
Two-way sensitivity analysis

Sensitivity Analysis
Willingness to Pay = $100,000/QALY

Cost of postnatal surgery for myelomeningocele (CPost)

Cost of prenatal repair

Postnatal repair
Prenatal repair
Limitations

• Evaluates a subset of pregnancies complicated by myelomeningocele

• Limited data on prenatal repair and quality of life for myelomeningocele patients

• Model does not include many indirect costs
Conclusions

• Prenatal surgery is cost saving in a majority of circumstances

• Maternal risks and the future reproductive plans of the pregnant women must be considered when discussing prenatal myelomeningocele repair

• The cost-effectiveness of prenatal repair is most sensitive to the cost of prenatal repair compared to postnatal repair
THANK YOU

QUESTIONS?

Somethings are priceless
References


2. Crane JMG, Hutchens D. Transvaginal sonographic measurement of cervical length to predict preterm birth in asymptomatic women at increased risk: a systemic review.


References

12. Catalog.ama.assn.org (based on TVUS, Medicaid reimbursement using Code 76817)
17. Russell RB et al. Cost of Hospitalization for Preterm and Low Birth Weight Infants in the United States
18. Waitzman NJ, Romano PS, Scheffler RM. Estimates of the economic costs of birth defects. 1994; 31: 188-205


