Fetal Therapy and Surgery: Operative Fetoscopy

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What this presentation will cover

• What is operative fetoscopy
• What can be done with operative fetoscopy
• What does not need to be done with operative fetoscopy
• What cannot be done with operative fetoscopy
• Who should do operative fetoscopy
• Where should operative fetoscopy be done
• Conclusions
The Fetus as a Patient

• Assumptions:
  – Identification and characterization of the disease or condition that affects the fetus
  – Treatment can be provided before birth to avoid death or impairment
The fetal patient:
Particular problems

- The intrauterine location of the fetus presents unique diagnostic and therapeutic challenges
- The mother is generally an innocent bystander
History of fetal therapy

- 1962: Intraabdominal fetal transfusion for Rh disease. Liley, Australia
- 1982: Vesicoamniotic shunt for bladder obstruction. Manning, Canada
- 1983: Transplacental treatment of fetal arrhythmias. Kleinman, USA
- 1985: Transplacental fetal adrenal suppression. Evans, USA
- 1989: Fetal thoracocentesis for cystic adenomatoid malformation of the lung. Nugent, USA
History of fetal therapy (continued)

- **1989:** Laser treatment for twin-twin transfusion syndrome. De Lia, USA
- **1990:** Open fetal surgery for diaphragmatic hernia. Harrison, USA
- **1991:** Thin-gauge embryofetoscopy. Quintero, USA
- **1993:** Umbilical-cord ligation for acardiac twin. Quintero, USA
- **1995:** Non-selective laser photocoagulation of vascular anastomoses for twin-twin transfusion syndrome. Ville, France
- **1995:** Fetal cystoscopy. Quintero, USA
History of fetal therapy (continued)

- 1996: Devascularization of a placental chorioangioma. Quintero, USA
- 1996: Endoscopic treatment of SCT. Hecher, Germany
- 1997: Transection of amniotic bands. Quintero, USA
- 1998: Selective laser technique for twin-twin transfusion syndrome. Quintero, USA
- 1999: Amniopatch. Quintero, USA
- 2000: Fetal laryngoscopy. Quintero, USA
- 2001: Lysis of obstructive ureterocele. Quintero, USA
History of fetal therapy (continued)

- 2003: Randomized clinical trial: Endoscopic tracheal occlusion for congenital diaphragmatic hernia. Harrison, USA

- 2004: Randomized clinical trial: Laser vs. amniocentesis for twin-twin transfusion syndrome. Senat, France

- 2007: Sequential selective laser photocoagulation of communicating vessels. Quintero, USA

- 2009: Observational trial: endoscopic tracheal occlusion for diaphragmatic hernia. Jani, Belgium

- 2010: Vesicoamniotic shunt with Q-shunt. Quintero, USA

- 2013: PLUTO trial: randomized clinical trial: expectant management vs. vesicoamniotic shunting for fetal lower urinary tract obstruction. Morris, UK
Fetal Therapy

Diagnosis ≠ Treatment
### Natural history of fetal disease

<table>
<thead>
<tr>
<th>Condition</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transient</td>
<td>Pleural effusions</td>
</tr>
<tr>
<td>Non-progressive</td>
<td>Club foot, cleft lip</td>
</tr>
<tr>
<td>Progressive damage</td>
<td>Hydronephrosis</td>
</tr>
<tr>
<td>Progressive, lethal</td>
<td>Hydrops</td>
</tr>
</tbody>
</table>
Fetal Therapy: Medical Considerations

Risks
- Maternal
- Fetal

Benefits
- Maternal
- Fetal
What is operative fetoscopy?

Minimally-invasive percutaneous approach to the amniotic cavity or fetus using combined ultrasound and endoscopic guidance

Operative fetoscopy
Key elements in the definition

• Minimally-invasive
  – < 4 mm in diameter

• Percutaneous
  – No need for laparotomy
  – No need for hysterotomy

• Ultrasound

• Endoscopy
Why minimally-invasive?
Risk of pregnancy loss

- Directly related to the degree of myometrial injury

Ultrasound

- Prenatal diagnosis
  - Differential diagnosis
  - Surgical criteria
- Monitor access to the uterus
- Monitor surgery
- Monitor post-operative course
Endoscopy

• Improved resolution over that of ultrasound
• Limited field of view
• Obscured view with bleeding
Fetoscopy: the early days

Thin-gauge embryofetoscopy
Quintero, 1991
Operative fetoscopy

Operative fetoscopy: Goals

- Address similar fetal entities as open fetal surgery
- Add new entities
- Minimize maternal and fetal morbidity
- Improve perinatal outcomes
What can be done with Operative Fetoscopy?
## Indications for Fetal Therapy 1990

### Open fetal surgery
- Congenital diaphragmatic hernia
- Cystic adenomatoid malformation of the lung
- Sacrococcygeal teratoma
- Acardiac twin
- Bladder obstruction

### Ultrasound-guided
- Fetal transfusions
- Fetal shunts
  - Bladder obstruction
  - Hydrothorax
Entities that can be addressed with Operative Fetoscopy

- Twins (and other multiples)
  - TTTS
  - TRAP and other discordant anomalous twins
  - SIUGR
- Congenital diaphragmatic hernia
- Fetal bladder outlet obstruction
- Chorioangioma
- Teratomas
Entities that can be addressed with Operative Fetoscopy. Non-lethal

- Amniotic bands
- Cardiac surgery
- ? Spina bifida
Twin-twin transfusion syndrome
Twin-twin transfusion syndrome

- Incidence: 5-15% of all monochorionic twins
- Monochorionic twins: 0.7% of all pregnancies
- TTTS: 0.07% of all pregnancies
- = ~2800 pregnancies in the United States
Natural history of TTTS

- 100/105 (95%) perinatal mortality
- Mechanisms of pregnancy loss:
  - Fetal demise
  - Preterm labor/miscarriage

TTTS
Pathogenesis

• Net flow of blood from the donor to the recipient (“The D-R score”) (Quintero et al. Prenat Neonat Med, 2000)

• Changes in umbilical venous flow after laser surgery (increase in the donor, decrease in the recipient)
Umbilical venous flow before and after laser surgery

Ishii et al. Ultrasound Obstet Gynecol 2004
• Donor
  – Activation of the renin-angiotensin system
  – Oliguria
  – “Hypotension”

TTTS
Pathophysiology

• Recipient
  – Increased atrial natriuretic factor
  – Polyuria
  – Hypertension (4xVmax^2)
  – Congestive heart failure
TTTS: definition

- Monochorionic
- Same gender
- Maximum vertical pocket of amniotic fluid volume: > 8 cm in one sac, < 2 cm in the other sac
MVP in singletons

Fig 2. Regression of single deepest pocket (lowest vertical pocket, LVP) on gestational age. Single deepest pocket = 2.12 + (0.398 × Gestational age) + (0.02 × Gestational age²) + (0.0005 × Gestational age³) + (0.00005 × Gestational age⁴). $R^2 = 0.92$. 

Magann et al. AJOG 2000;1581-8
Should we use an MVP of 10 cm after 20 weeks (Eurofetus)?
MVP in the Recipient twin relative to +/- 20 weeks

Staging of twin-twin transfusion syndrome
Staging of TTTS

- Stage I: Bladder of Donor still visible
- Stage II: Bladder of Donor not visible
- Stage III:
  - AEDV/REDV in umbilical artery
  - Reverse flow in ductus venosus
  - Pulsatile umbilical-venous flow
- Stage IV: Hydrops
- Stage V: Fetal demise

Stage I:
Donor bladder is visible
Stage II: Donor bladder is not visible
Stage III
Absent or reverse end-diastolic velocity in the Umbilical Artery
Stage III:
Reverse flow in the DV
Stage III: Pulsatile umbilical-venous flow
Stage IV Hydrops
Stage V
Empiric staging system
(based on observation, not on surgical results)

Original Article

Staging of Twin-Twin Transfusion Syndrome

Rubén A. Quintero, MD
Walter J. Morales, MD, PhD
Mary H. Allen, RN
Patricia W. Bornick, RN, MSN
Patricia K. Johnson, RDMS
Michael Kruger, MA

CONCLUSION:
Staging of TTTs using the proposed criteria has prognostic significance.
This staging system may allow comparison of outcome data of TTTs
with different treatment modalities.

Twin-twin transfusion syndrome (TTTS) occurs in 10% to 17% of
monochorionic pregnancies. The syndrome is defined embryologi-
Laser treatment of twin-twin transfusion syndrome
RATIONALE FOR LASER SURGERY IN TTTS
Rationale

1. TTTS does not occur in dichorionic twins* (*where there are no placental vascular anastomoses)
2. TTTS occurs via placental vascular anastomoses
3. TTTS should disappear if the placental vascular anastomoses are eliminated
Non-selective laser therapy

• Laser of all vessels crossing the membrane
• Replaced uncertainty about separation of the fetal circulations
• Reproducibility
Dividing membrane vs vascular equator
The non-selective technique may not target the right vessels
Selective technique: SLPCV

Quintero et al. Obstet/Gynecol Surv. 1998
Non-selective
Effectiveness of laser treatment

- Comparison between selective laser and serial amniocentesis (non-randomized)

Laser vs. amniocentesis by Stage

Comparison between selective laser and serial amniocentesis by Stage (non-randomized)

Does it matter to do a selective vs. non-selective technique?
Selective vs. non-selective
At least one survivor
N = 440

Quintero et al, in preparation
Is the laser experience similar among centers?
NIH trial vs. Quintero
2007

* = p < .05
TTTS: what to expect from laser treatment

• Ability to complete the surgery: >98%
• Ability to perform a selective technique: >95%
• Ability to treat, independent of placental location
• Survival: 90% for at least one fetus
• Dual survival: 65-75%
• Gestational age at delivery: >33 weeks
• Neurological sequelae: <10%
• Patent anastomoses: <5%
• Reverse or persistent TTTS <5%
TTTS: What not to expect

- Persistent or reverse TTTS
- Umbilical cord occlusion for Stage III-IV
- Adverse effects to the surviving twin after demise of the co-twin
Congenital diaphragmatic hernia
CDH: The problem

• Pulmonary hypoplasia and pulmonary hypertension secondary to space-occupying lesion from the abdominal contents
CDH: Incidence

- 0.033-0.05 % of all births
- 1:3333 of all pregnancies
- 0.01 % pediatric surgery cases
- Female:male ratio: 2:3, 1:4
CDH: The treatment?

- Correct the hernia in utero
- Block the fetal airway (tracheal occlusion)
First historical approach:
In utero repair of CDH via open fetal surgery
CDH – In utero surgical repair
Randomized clinical trial

11 patients with CDH

• Surgery: 4
• Survival: 3 (75%)
  – Required ECMO: 0
• Postnatal care: 7
• Survival: 6 (86%)
  – Required ECMO: 1

Conclusion: In utero surgery is not superior to expectant management

Experimental tracheal occlusion

- Prevents development of pulmonary hypoplasia in fetuses with CDH
- Enhances normal pulmonary maturation
- Growth is due to hyperplasia not hypertrophy
- Lung expansion may even push stomach and bowel contents back into the abdomen

Di Fiore et al. J Ped Surg 1994
Second historical approach:
Tracheal occlusion via open fetal surgery
(Extraluminal TO)
Extraluminal tracheal occlusion

- 15 patients
- 5 survivors: 33%
- 4/5: neurological damage

Randomized clinical trial:
Expectant management vs. TO
## Results

24 patients with CDH

<table>
<thead>
<tr>
<th></th>
<th>Expectant</th>
<th>TO</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>GA del</td>
<td>37</td>
<td>30.8</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Survival</td>
<td>10/13 (77%)</td>
<td>8/11 (73%)</td>
<td>NS</td>
</tr>
<tr>
<td>Neurologic morbidity</td>
<td>3/4</td>
<td>2/6</td>
<td>NA</td>
</tr>
</tbody>
</table>
### Table 2. Pregnancy Outcomes and Complications According to the Actual Treatment.*

<table>
<thead>
<tr>
<th>Outcome or Complication</th>
<th>Standard Care (N=13)</th>
<th>Tracheal Occlusion (N=11)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal death — no. (%)</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Maternal blood transfusion — no. (%)</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Maternal infection (wound) — no. (%)</td>
<td>0</td>
<td>1 (9)</td>
<td></td>
</tr>
<tr>
<td>Preterm labor — no. (%)</td>
<td>4 (31)</td>
<td>8 (73)</td>
<td>0.10</td>
</tr>
<tr>
<td>PROM — no. (%)</td>
<td>3 (23)</td>
<td>11 (100)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Time from tracheal occlusion to PROM — days</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>24.8±14.8</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td></td>
<td>5–52</td>
<td></td>
</tr>
<tr>
<td>Time from PROM to delivery — days</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>&lt;1</td>
<td>9.5±8.5</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>0–28</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Placental abruption — no. (%)</td>
<td>1 (8)</td>
<td>3 (27)</td>
<td>0.30</td>
</tr>
<tr>
<td>Mode of delivery — no. (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planned EXIT</td>
<td></td>
<td>11 (100)</td>
<td></td>
</tr>
<tr>
<td>Induced vaginal delivery</td>
<td>12 (92)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Cesarean delivery</td>
<td>1 (8)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Gestational age at delivery — wk</td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Mean</td>
<td>37.0±1.5</td>
<td>30.8±2.0</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>34.0–39.0</td>
<td>28.0–34.0</td>
<td></td>
</tr>
<tr>
<td>Birth weight — kg</td>
<td>3.03±0.48</td>
<td>1.49±0.36</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

* Plus–minus values are means ±SD. PROM denotes premature rupture of the membranes, and EXIT ex utero intrapartum therapy.
### Table 3. Ninety-Day Survival According to Assigned and Actual Treatment and According to the Lung-to-Head Ratio.

<table>
<thead>
<tr>
<th>Group</th>
<th>Lung-to-Head Ratio</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \leq 0.78 )</td>
<td>( 0.79 - 1.06 )</td>
</tr>
<tr>
<td><strong>Assigned treatment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard care</td>
<td>0/0</td>
<td>6/9 (67)</td>
</tr>
<tr>
<td>Tracheal occlusion</td>
<td>0/1</td>
<td>7/9 (78)</td>
</tr>
<tr>
<td><strong>Actual treatment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard care</td>
<td>0/0</td>
<td>8/11 (73)</td>
</tr>
<tr>
<td>Tracheal occlusion</td>
<td>0/1</td>
<td>5/7 (71)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>0/1</td>
<td>13/18 (72)</td>
</tr>
</tbody>
</table>

* \( P = 0.04 \) for a trend of increased survival with a higher lung-to-head ratio (non-parametric test for trend).
RCT outcome
Survival analysis overall

Harrison et al. NEJM 2003
RCT outcome
Survival analysis by LHR

Harrison et al. NEJM 2003
Lung-to-head ratio

HC: 226 mm
Right lung:
- 10.3 x 22.4 mm
LHR: 1.07
What is the biomedical challenge?

• Intraluminal technique
• Reversible
• Innocuous (fetal)
• Innocuous (maternal)
• 2-3 weeks’ duration
• Grow with the trachea
Third historical approach: Percutaneous intraluminal tracheal occlusion

- Percutaneous approach (Direct fetal laryngoscopy)

Severe diaphragmatic hernia treated by fetal endoscopic tracheal occlusion

J. C. JANI†*, K. H. NICOLAIDES†, E. GRATAÇÓS‡, C. M. VALENCIA†, E. DONÉ*, J.-M. MARTINEZ‡, L. GUCCIARDO*, R. CRUZ‡ and J. A. DEPREST*

Fetal Medicine and Treatment Units of *University Hospital Gasihuisberg, Leuven, Belgium, †King’s College Hospital, London, UK and ‡Hospital Clinic, Barcelona, Spain

KEYWORDS: congenital diaphragmatic hernia; fetal therapy; fetal tracheal occlusion; lung-to-head ratio; pulmonary hypoplasia
CDH TO observational trial

- 210 patients
  - 175 LCDH with an LHR <1
  - 34 RCDH
  - 1 Bilateral

- Technical success: 96.7% (203/210)

Jani et al, 2009
CDH TO Observational trial

• Median GA at Sx: 27.1 weeks (23-33)
• GA delivery: 35.3 (25-41)
  – 30.9% <34 weeks (65/210)
• PROM: 47.1% (99/210)
  – Median 30 days, range 3-83
  – 16.7% (35/210) within 3 weeks of the procedure

Jani et al, 2009
CDH Observational trial

- 97.1% (204/210) born alive
  - 3% intrauterine fetal demise
- 10 babies died at the time of C/S from difficulties removing the balloon

Jani et al, 2009
CDH TO observational trial

• Survival LCDH: (86/175): 49.1%
  – Compared to 24% untreated (regression analysis from prior series)
    • survival rate (%) = (258 × (o/e LHR (%)) – 28.68)/100

• Survival RDCH: (12/34): 35%
  – Compared to 0% controls (regression analysis)

Jani et al, 2009
Problems with the balloon technique

- Balloon does not grow with the trachea
- Balloon may not continue to occlude the trachea after certain period of time
- Problems with removal of the balloon
  - Fetal death during delivery
- Balloon requires removal 4-6 weeks later
  - Repeat fetoscopy
  - Ultrasound-guided puncture
  - Risk of fetal death/injury
Balloon removal

- Puncture: 19.6%
- Post-natal: 16%

Table 1 Method of balloon removal

<table>
<thead>
<tr>
<th>Reason</th>
<th>Method</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elective</td>
<td>EXIT</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Fetoscopic removal</td>
<td>71</td>
</tr>
<tr>
<td></td>
<td>Ultrasound-guided puncture</td>
<td>11</td>
</tr>
<tr>
<td>Emergency</td>
<td>EXIT</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Fetoscopic removal</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Ultrasound-guided puncture</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>Postnatal tracheoscopic removal</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Postnatal puncture through the neck</td>
<td>13</td>
</tr>
</tbody>
</table>


Jani et al, 2009
Behavior of the LHR in pregnancy

LHR over time

Quintero et al. AJOG 2011
Quantitative lung index: A gestational-age independent marker of fetal right lung growth

**FIGURE 3**
QLI with results from division of right lung area by head circumference squared multiplied by 100

Graph shows that QLI is approximately 1 throughout pregnancy.

*QLI, quantitative lung index.
Quintero TO technique

- Intraluminal
- Percutaneous
- Modified Z-stent
- Easy removal of stent
Experimental evidence. Tracheal occlusion with modified Z-stent

Control

CDH untreated

CDH treated

Sosa-Sosa, Bermúdez, Chmait, Kontopoulos, Quintero et al. 2012
Clinical Tracheal Occlusion
Comparison of techniques

<table>
<thead>
<tr>
<th></th>
<th>Balloon</th>
<th>Quintero Z-stent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percutaneous</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Intraluminal</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Grows with the trachea</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Obstructs for 4 weeks</td>
<td>?</td>
<td>+</td>
</tr>
<tr>
<td>Does not obstruct &gt;4 weeks</td>
<td>?</td>
<td>+</td>
</tr>
<tr>
<td>Does not need removal &gt; 4 weeks</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Can be easily removed at birth</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>
CDH: What to expect from tracheal occlusion:

- Ability to block the trachea: >90%
- Survival:
  - 50% Left-sided CDH
  - 35% Right-sided CDH
- Gestational age at delivery: >34 weeks
- Neurological morbidity:
  - <50% (?)
CDH: What not to expect from tracheal occlusion:

- Need to perform open fetal surgery
- Lack of pulmonary growth/development
Fetal bladder outlet obstruction
Fetal bladder obstruction: A novel therapeutic approach
LUTO: The problem

• Expectant management:
  – Hydronephrosis
  – Renal cystic dysplasia
  – Pulmonary hypoplasia

• Perinatal mortality: up to 90%

LUTO: Incidence

- Renal sonographic abnormalities occur in 0.2% of all pregnancies
- Dilated fetal uropathy is present in 1:800 pregnancies
- Obstructive uropathy represents 23% of dilated fetal uropathy
- 1:3000
- Approximately 1300 cases per year in the US

LUTO: The treatment

- Vesicoamniotic shunt (VAS)
- Open vesicostomy
- Cystoscopy
- Cystoscopy with new Q-shunt
Complications of vesicoamniotic shunting

- Catheter is expelled or pulled into the amniotic cavity
- Catheter pulls into the fetal abdomen
- Catheter in place, drainage into peritoneal cavity

40-60% complication rate

Vesicoamniotic shunt
In place
Shunt dislocation

Out of the bladder

Out of the skin

Out of the bladder and skin
Bladder neck:
Absent dilatation
Urethra: Posterior urethral valves
PLUTO trial

- Multicenter randomized controlled trial. Percutaneous shunting for lower urinary tract obstruction (PLUTO), will evaluate the benefit of vesicoamniotic shunting as compared to conservative treatment as measured by perinatal and postnatal mortality and renal outcomes.

Innovative therapy for LUTO: The Q-shunt
Intraoperative ultrasound
Q-shunt at birth
Vesicoamniotic shunting
Fetal Surgery Pioneer Invents Life-Saving Device for Unborn Babies

During a routine ultrasound, doctors determined that Carla Datorre-Pearson’s unborn son suffered from a lower urinary tract obstruction (LUTO). The condition prevents a fetus from eliminating urine from its body while developing in the womb. Without treatment, 90 percent of the babies affected by LUTO die.

Carla was referred to Rubén A. Quintero, M.D., director of the University of Miami Division of Maternal-Fetal Medicine and the Fetal Therapy Center at the Women’s Hospital Center of Jackson Memorial Hospital, who is a worldwide leader in fetal therapy. In September, he placed a tiny shunt—which he and his team had recently invented—in the baby in Carla’s womb. Andre Pearson was born healthy in January.

Channel 7 covered this story.

Carla Datorre-Pearson calls son Andre her miracle baby. “If it wasn’t for this surgery, my son would not have survived,” she said.
LUTO: What to expect

• Vesicoamniotic shunt:
  – 40-60% malfunction

• Survival: classic figures:
  – 30% survival
  – 30% survival with significant morbidity
  – 30% loss, regardless of treatment

• Fetal loss: 4%
LUTO: What not to expect

• Treatment before 16 weeks
• Treatment of co-twin following standard algorithm
• Vesicoamniotic shunt placed in the myometrium
Discordant anomalous monochorionic twins
Discordant anomalous monochorionic twins: The problem

- Cardiovascular compromise to the healthy twin
  - Polyhydramnios
  - Hydrops
  - Pregnancy loss
- Polyhydramnios (e.g., anencephaly)
- Neurological damage or co-demise of the co-twin after death of the anomalous twin
TRAP sequence

• Incidence:
  – 0.3:10,000 births
  – 1% of monozygotic twins

• Pregnancy type:
  – 75% triplets
  – 25% twins

• Prognosis:
  – Perinatal mortality: 50% donor twins
  – Best prognosis: small acardiac.
PATHOPHYSIOLOGY

TRAP twin

Pump twin

Umbilical vein

Artery with reversed flow

Umbilical vein

Artery

“Used”, deoxygenated blood
  → caudo-cranial perfusion gradient
  → upper body disruption

Abnormal vessels connections
  umbilical artery < SMA
  umbilical vein > iliac veins

Increased cardiac load
  → High output failure
  → Polyhydramnios
  → Hydrops
  → Premature delivery
Discordant anomalous monochorionic twins: the treatment

- Umbilical cord occlusion of the anomalous twin
  - Polyhydramnios
  - Evidence of hemodynamic impairment to the normal twin
  - Preterm labor
  - Shortened cervix
Umbilical cord occlusion for discordant anomalous twins

- Ligation
- Laser
- Bipolar electrocoagulation
- Radiofrequency
- Intravascular methods
Umbilical cord ligation

Quintero et al. NEJM 1984
Laser of the cord
Thrombosis after laser occlusion of VV anastomosis
Umbilical cord occlusion

- Ligation
- Laser
- Bipolar electrocoagulation
- Radiofrequency
- Intravascular methods
Discordant anomalous monochorionic twins: What not to expect

- Demise of the normal twin as a result of the surgical procedure
- Late demise of the normal twin as a result of thermal damage to the venous return
Chorioangioma
Teratomas
Chorioangioma: Incidence/problem

- 1: 3,500-9,000 live births
- Mortality 18-40%
- Fetal morbidity from:
  - Preterm delivery
  - Coagulopathy
  - High output heart failure from AV shunting
Chorioangioma: The treatment

- **Work-up**
  - Diagnosis of fetal anemia
  - Hemodynamic compromise
  - Anatomy of the vascular supply of the mass

- **In utero devascularization**
Chorioangioma
MCA-PSV

2.3 MOMs
Chorioangioma: Vascular supply
In utero devascularization of chorioangioma
Chorioangioma: what to expect

- No further flow to the chorioangioma
- No sonographic evidence of fetal anemia
Chorioangioma: what not to expect

- Demise of the fetus as a result of surgery
Amniotic bands
Amniotic band syndrome: The problem/incidence

• 1:1,200 live births
• 50% will have associated anomalies
  • Cleft lip/palate
  • Clubfoot deformity
• Constriction of appendages
  • Congenital lymphedema
  • Congenital amputation
Amniotic bands

- Risk of spontaneous limb amputation

Limb amputation in amniotic band syndrome: serial ultrasonographic and Doppler observations

O. P. Tadmor, G. A. Kreisberg*, R. Achiron†, S. Porat‡ and S. Yagel**

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Amniotic band: the treatment

• Lysis of the amniotic bands
Lysis of amniotic bands

Scissors

Arm

Constriction

[Image of an ultrasound scan with annotations pointing to an arm and a constriction symbol.]
Significance of lysis of amniotic bands

- New indication for operative fetoscopy
- Treatment of non-lethal pathology
Amniotic bands: what to expect

• Decreased distal edema
• Lack of amputation
Amniotic bands: what not to expect

• Complete resolution of the constriction
• Lack of sequelae from constriction
In utero removal of an oral teratoma
Teratomas

• 1/4000 live births
  – Head and neck occurrence comprises 1-10%

• Composed of multiple tissues foreign to the site from which they originate
  – Ectoderm, mesoderm, and endoderm

• Commonly arise in a midline or paraxial location from the brain to the sacral area
  – Most located in sacrococcygeal region
15 Case Reports

- **Age at Diagnosis:**
  - 10 at birth; 5 prenatally through US
- **Location:**
  - 7 tongue, 8 hard palate
- **Size:**
  - Range from 1-13cm
- **Outcome:**
  - 7 living, 5 death, 3 TOP: ~50% survival
Management

• Delivery by elective cesarean section
• EXIT procedure if needed
• Tracheostomy if needed
• Post-natal resection
Case presentation

- 37 yo G4P1021 at 20 weeks’ gestation

- Ultrasound at outside facility at 16 weeks: normal

- Repeat ultrasound at 18 weeks:
  - Pedunculated mass protruding from mouth measuring 2.1 x 1.7cm

- Fetal MRI: exophytic cystic mass arising from left paramedian aspect of midface of the fetus, suggestive of an oral teratoma

- Amniocentesis: 46, XX
Ultrasound at 20 weeks

- Complex mass arising from fetal mouth measuring 4.1 x 2.4 x 2.8 cm
- Cystic and solid components
- No evidence of clefting
- Small feeding vessel identified at base
- Anatomical site of origin could not be determined
- Anatomy otherwise normal
- No polyhydramnios, hydrops, or abnormal Dopplers
- Normal fetal Echo
Counseling

• Expectant Management
  – Development of polyhydramnios, hydrops, IUFD
  – Delivery by c/s with EXIT

• Termination

• Diagnostic Fetoscopy
In utero resection of oral teratoma
Fetoscopic resection of an oral teratoma

- Post-operative ultrasound shows normal profile

- Mass left in the amniotic cavity, measured 3.9 x 2.5 x 1.7cm
No evidence of residual tumor
No evidence of injury
A new approach to fetal lung masses

Fetal Bronchoscopy
Fetal lung masses

- CCAM or CPAM
- Pulmonary sequestration
- Congenital lobar emphysema
- Bronchogenic cysts
CCAM/CPAM

- Incidence: 1:25,000-1:35,000
- Represent 30-40% of fetal lung masses
- 85% unilobar
- Communicates with airway
- Vascularization from pulmonary bed
- 40% complicated by hydrops
- 10% spontaneous regression
Pulmonary sequestration

- Systemic blood supply
- Intralobar/extralobar
  - Extralobar: male:female ratio 3:1
  - 20% have infradiaphragmatic feeding vessel from the aorta
  - Intralobar: may communicate with esophagus, stomach
Fetal Bronchoscopy

• 24 yo, G4, P1
• 27 5/7 weeks
• Fetal left lung mass
• No obvious left lung
• Right lung collapsed
Right lung
Bronchial tree: segmentation and lung relation
Documentation of the bronchoscopy and bronchial relations

Main right bronchus
- Documentation of the bronchoscopy and bronchial relations

Lower lobe right bronchus
Documentation of the bronchoscopy and bronchial relations

Main left bronchus
Documentation of the bronchoscopy and bronchial relations

B1

B2+3

B4+5

Observe the subsegmentation

Upper left bronchus
Documentation of the bronchoscopy and bronchial relations

Upper left bronchus
Documentation of the bronchoscopy and bronchial relations

Lower left bronchus

B Basalis of Lower left lobe

Lower left bronchus
Documentation of the bronchoscopy and bronchial relations

Debris and “plugs”
Fetal bronchoscopy
Pre-op

Intra-operative ultrasound after bronchoscopy

- Multiple hyperechogenic speckles from bronchial lavage
- Intraoperative expanded right lung
- Echogenic lung mass
- Intraoperative expanded left lower lobe
QLI before and after fetal bronchoscopy

Right QLI

Gestational age (weeks)

0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9

25 27 29 31 33 35 37 39
CASE REPORT

Fetal bronchoscopy: its successful use in a case of extralobar pulmonary sequestration

Ruben A. Quintero¹, Eftichia Kontopoulos¹,², Joel Reiter³, Wilson L. Pedreira⁴ & Andrew A. Colin³

¹Divisions of Fetal Therapy, ²Maternal-Fetal Medicine, Department of Obstetrics and Gynecology, ³Division of Pediatric Pulmonology, Department of Pediatrics, Miller School of Medicine, University of Miami, Miami, FL, USA, and ⁴Fleury Group – Medicine in Health, Senior consultant – Pulmonary Division, Sao Paulo, Brazil
What cannot be done with operative fetoscopy
What should not be done with operative fetoscopy

- Fetal transfusions
- Pulmonary sequestration (?)
- CCAM (?)
- Other ultrasound-guided procedures
Who should do operative fetoscopy?

- Physicians with ultrasound and endoscopy skills
  - Ultrasound skills only
    - Inability to solve surgical challenges
  - Endoscopy skills only
    - Inability to target surgical task properly
    - Inability to realize complications
  - Neither
Training in operative fetoscopy

- None
- One day
- One week
- One month
- 6 months
- One year
Where should operative fetoscopy be done?

• Main operating room
Conclusions

• Fetal Therapy and Fetal Surgery via Operative fetoscopy is an exciting, challenging clinical discipline
• Operative fetoscopy has essentially replaced open fetal surgery
Conclusions

• Operative fetoscopy provides hope to families affected by fetal conditions requiring in utero surgical repair
Thank you!
...Yale University, *circa* 1990