

15. MINIMALLY INVASIVE FETAL THERAPY

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HISTORICAL PERSPECTIVE

- *-First reported fetal treatment 1967*
 - Liley: percutaneous fetal blood transfusion for rhesus disease.
 - Initially blind procedures – ultrasound guidance introduced later
- *Widespread application of ultrasound-guided techniques*
 - Diagnostic procedures: amniocentesis, chorionic villous sampling, skin biopsy (see chapter 5)
 - Therapeutic techniques: drainage of amniotic fluid (amnioreduction), pleural effusion, bladder obstruction
- *Development of endoscopic techniques*
 - Spin-off of laparoscopic surgery (early 1990's)
 - Less invasive than open fetal surgery (comparable to needle techniques?)
 - Often combination of endoscopy, needle technique, ultrasound
 - Requires high level of expertise, tertiary center
 - Example: severe twin-to-twin transfusion syndrome (see chapter 14)

TYPES OF FETAL INTERVENTION

Non-invasive intervention

- *Transplacental therapy*
 - No direct violation of amniotic cavity
 - Administer medication to mother to affect fetus
 - Examples: Maternal digoxin to treat fetal supraventricular tachycardia or acardiac twin-associated hydrops of the normal twin

- **Minimally invasive intervention**

- Requires entering the gravid uterus – needle, incision
- More aggressive form of fetal treatment
- Significant risks: infection (wound, chorioamnionitis), bleeding (uterus, fetus), tear/rupture of amniotic or chorionic membrane, premature labor, chronic amniotic leak (and oligohydramnios)
- Significant risk of fetal death – depends on invasive nature *and* severity of disease
- Needle techniques *vs.* endoscopic fetal surgery
- Single *vs.* multiple ports

INDICATIONS FOR MINIMALLY INVASIVE FETAL INTERVENTION

Very few fetal anomalies meet above criteria (see rationale). Several are described in more detail elsewhere in the syllabus.

- ***Aqueductal stenosis (isolated hydrocephalus)***

- Isolated obstruction of CSF flow at level of aqueduct (4th ventricle)
- Leads to isolated hydrocephalus
- Originally treated with (percutaneous) ventriculoamniotic shunt
- Complications: bleeding, dislodgement (fetus pulls catheter out)
- Neurological outcome: paradoxically worse than untreated group (untreated hydrocephalus often leads to fetal demise ; with shunt, fetus survives with neurological deficit)
- Now abandoned

- ***Bilateral urinary tract obstruction (see chapter 8)***

- Rationale: bladder outlet obstruction (mostly males, posterior urethral valves) leads to 1) hydronephrosis, renal damage, and 2) oligohydramnios, pulmonary hypoplasia, neonatal death from respiratory failure Treatment aims at restoring urine flow
- Treatment options:
 - vesicoamniotic shunt (double pigtail catheter): often dislodged
 - endoscopic cystostomy: reported, but rarely if ever performed today
 - fetal cystoscopy: although described (destruction of urethral valves by laser via cystoscope), not yet acceptably safe and effective
- Difficulties: Only justified if kidney function preserved (i.e., urine production); in reality, difficult to predict renal function (urine electrolytes, β_2 -microglobulin, ultrasound criteria). Even if successful (i.e., amniotic fluid restored), chronic renal failure (and transplantation) often unavoidable

- ***Congenital lung cyst and pleural effusions***
 - Uni- or bilateral pleural effusions:
 - If part of systemic manifestation (i.e., hydrops)
 - Treat underlying condition first
 - May represent poor prognosis
 - If isolated or idiopathic: risk of pulmonary compression and pulmonary hypoplasia
 - Placement of pleuro-amniotic shunt (double-pigtail catheter) well described
 - Risks: dislodgement, rupture of membranes, injury to intrathoracic organs
 - Large congenital lung cysts/masses (see chapter 7): CCAM, sequestration, Bronchogenic cyst
 - Most lesions asymptomatic
 - May enlarge rapidly in second trimester
 - If very large: lung compression (pulmonary hypoplasia), mediastinal shift (hydrops)
 - Most lesions (80-85%) regress early in third trimester
 - Fetal intervention *only* if impending hydrops
 - If mostly cystic (single large cyst): percutaneous drainage
 - If mostly solid or microcystic: Open fetal surgery and resection (see chapter 16)
 - Experimental techniques: radiofrequency ablation
- **Other indications for fetal surgery**
 - Cardiac anomalies (see chapter on fetal cardiology) (see chapter 10):
 - In general, fetal heart surgery not possible (animal models exist)
 - Hypoplastic left heart syndrome (HLHS): *may* be caused by aortic valve stenosis in early gestation
 - Balloon valvuloplasty in utero “prevents” development of HLHS?
 - Early results mixed, but promising
 - Twin-to-twin transfusion syndrome (see chapter 14):
 - Most commonly performed fetal surgical procedure today (> 2,000 cases worldwide)
 - Aim: obliteration (laser) of communicating vessels between two twins, in monochorionic gestation (single placenta)
 - Eurofoetus randomized controlled study (150 patients): proven survival advantage over other forms of treatment (amnioreduction)

- Congenital diaphragmatic hernia (see chapters 7 and 16):
 - Experimental evidence that in utero tracheal occlusion causes accelerated lung growth. Clinical application of this principle is feasible, but experimental.
 - Fetal tracheoscopy/tracheal balloon: Elegant, minimally invasive technique, but results mixed at best. Results currently worse than with postnatal treatment (including ECMO).
 - European trial of in utero tracheal occlusion, followed by release of occlusion, is ongoing – with promising early results

TECHNICAL ASPECTS OF FETAL INTERVENTION

Ultrasound-guided techniques

- Single needle approach: amniocentesis, fetal bladder puncture, chorionic villous sampling, in utero blood transfusion
 - Local anesthesia
 - Complication rate (bleeding, chorioamnionitis, membrane tear, fetal trauma) relatively low
 - Post-procedure uterine contractions: usually short-lived, do not progress to labor
 - Uterus more irritable in third trimester
- Advanced procedures: shunts (vesicoamniotic, pleuroamniotic, ventriculoamniotic)
 - Complication rate higher – risk of premature labor
- “Surgical” techniques: sporadic reports (ultrasound-guided umbilical cord occlusion for acardiac twin)

Minimally invasive (endoscopic) fetal surgery

- Spin-off from laparoscopic surgery *meets* spin-off from open fetal surgery (see chapter 16)
- Specialized instruments, uterine access (atraumatic penetration of myometrium, membranes)
- Working medium: fluid (saline, Ringers) preferable to gas (CO₂)
- Percutaneous or via mini-laparotomy; epidural or general anesthesia
- Laboratory and clinical evidence that endoscopic surgery (“FetEndo”) is less traumatic than open fetal surgery: fewer postoperative contractions, no mandatory C-section
- Complications increase with increasing number and diameter of trocars/instruments
- Indications: Twin-to-twin transfusion syndrome, acardiac twin, diaphragmatic hernia (tracheal occlusion – current moratorium), urinary tract obstruction (uncommon today). Experimental: endoscopic radiofrequency ablation for tumors, CCAM