



Anaesthesia for fetal surgery

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History of fetal surgery

- 1965 - first **intrauterine transfusion** for hydrops due to Rh incompatibility by A.W.Liley [L SEP]
- 1974 - **fetoscopy** to obtain fetal samples by Hobbin [L SEP]
- 1981- **fetoscopic transfusion** by Rodeck [L SEP]
- 1982 - first **open fetal surgery** for obstructive uropathy by Dr. Michael Harrison, University of California, San Francisco

What is fetal surgery?

It is application of established surgical techniques to the **unborn baby**

- during gestation

- at the time of delivery

- ✓ fetal intervention is reaching **inside the uterus**
- ✓ many diseases can now be accurately **diagnosed before birth**
by genetic and imaging techniques
- ✓ **maternal - fetal intervention**
- ✓ **the safety of the mother**

Contraindication for fetal surgery

- ✓ conditions incompatible with life
- ✓ chromosomal and genetic disorders
- ✓ other associated life threatening abnormalities
- ✓ usually performed between 24-29 weeks gestation

Requires combined expertise of

**[L
SEP]**

- ✓ **Obstetrician**
- ✓ **Anaesthesiologist**
- ✓ **Neonatologist**
- ✓ **Pediatric surgeon**

Indications For Fetal Surgery

1. **Anatomic lesions** that interfere with development:

- **Bilateral obstructive hydronephrosis or lower urinary tract obstruction**
- **Obstructive hydrocephalus**
- **Congenital diaphragmatic hernia(CDH)**
- **Cardiac anomalies-complete heart block, AS, PS**
- **Neural tube defects –spina bifida, sacrococcygeal teratoma, myelomeningocele**
- **Skeletal defects**
- **Gastroschisis**
- **Thoracic space occupying lesions**
- **Giant neck masses**
- **Tracheal atresia-stenosis**
- **Congenital cystic pulmonary adenomatoid malformation (CCAM)**
- **Craniosynostosis**
- **Cleft lip and palate**
- **Hydrothorax**

Indications For Fetal Surgery

2. Anomalies associated with twins

TTTS - twin-twin transfusion syndrome

TRAP- twin reverse arterial perfusion

3. Anomalies of placenta, cord or membranes

Amniotic band

Chorioangioma

Types of fetal surgery

Open fetal surgery

Human Fetal Myelomeningocele Repair



OPEN SURGERY	Hysterotomy	<ul style="list-style-type: none"> • CCAM – Lobectomy • SCT – Resection • MMC – Repair • Cervical Teratoma – Resection • EXIT <ul style="list-style-type: none"> Tracheal occlusion Neck tumors CDH (EXIT to ECMO) CCAM (EXIT lobectomy)
FETENDO	Fetoscopic Surgery	<ul style="list-style-type: none"> • Balloon Occlusion of Trachea (for CDH) • Laser Ablation of Vessels (for TTTS) • Cord Ligation/Division • Cystoscopic Ablation Valves (Urinary Obstruction) • Amniotic Bands Release
FIGS	Fetal Image Guided Surgery	<ul style="list-style-type: none"> • Amnioreduction/Infusion • Fetal Blood Sampling • RFA Anomalous Twins • Vesico/Pleuro Amniotic Shunts • Balloon Dilation Aortic Stenosis
EXIT procedure	Planned Specialized Delivery	<ul style="list-style-type: none"> • <u>CHAOS</u> • Removal of the CDH Tracheal Occlusion Balloon • Pulmonary Sequestration • CCAM

**CHAOS - Congenital High Airway Obstruction Syndrome; CCAM - congenital pulmonary airway malformation; CDH - congenital diaphragmatic hernia;
STC - sacrococcygeal teratoma; TTTS - Twin to Twin Transfusion Syndrome; RFA - Radio-Frequency Ablation**

Open surgery

Most definitive and most invasive
Performed – middle of pregnancy

Mother anaesthetised by GA

Uterus opened similar to LSCS

Intraoperative sonography – locate the placenta

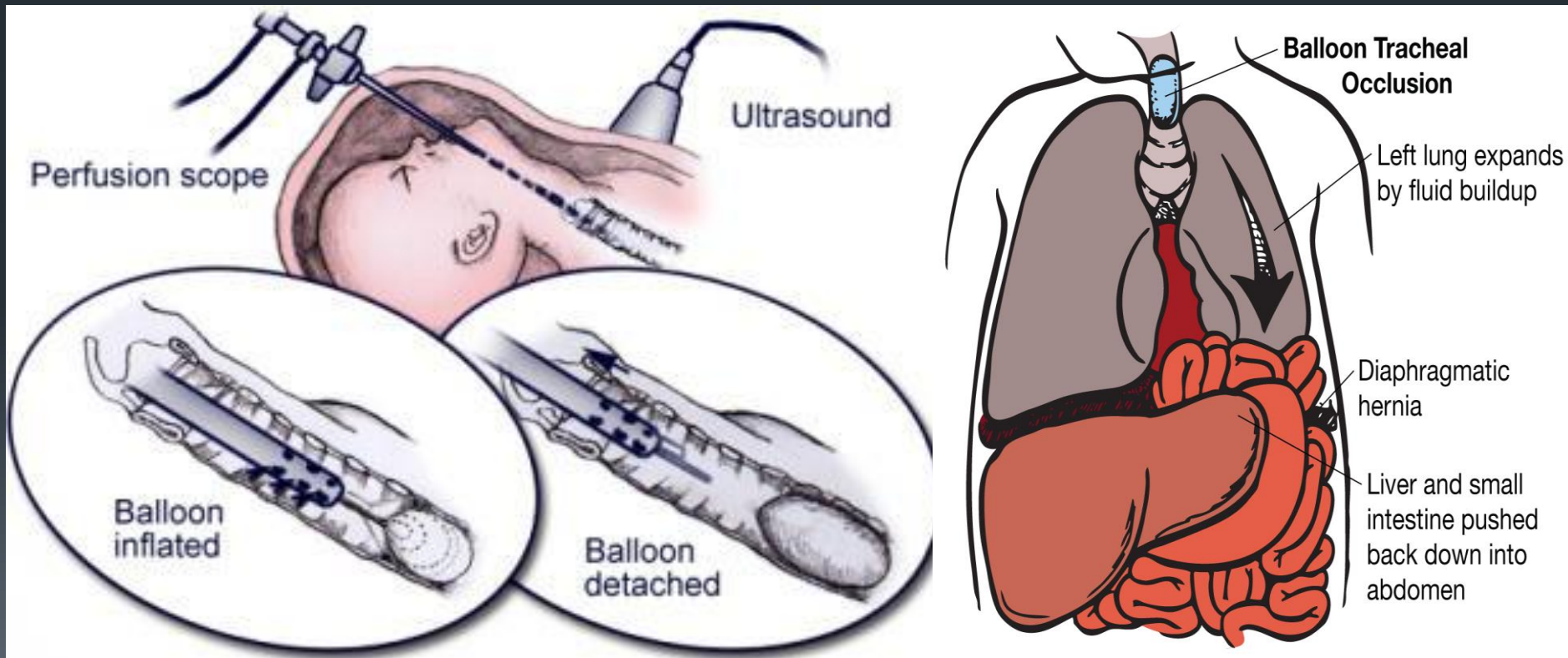
Incision taken close to the area of interest

Fetal part is exteriorized

Surgical repair of fetus done

Types of fetal surgery

FETENDO - Fetal endoscopic surgery or fetoscopy (minimally access fetal surgery - MAFS)



FETENDO - fetal endoscopic



- ✓ developed in the *1990s*
- ✓ *very small endoscopes*, with very small instruments
- ✓ the best method of seeing the fetus in real-time is to use both *endoscopic*, and *sonographic*
- ✓ combination of image-guided manipulation and sonographically - guided manipulation
- ✓ *percutaneous* or, in some circumstances, *mini-laparotomy*

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FETENDO - fetal endoscopic

The advantages

- *less invasive* than open fetal surgery
- mother's postoperative *recovery is easier*
- *less preterm labor* (not eliminated the problem)
- replaced open fetal surgery
- particularly useful for treating *problems with the placenta*
- useful *for looking inside* the fetus

“yes.... **BUT!**”

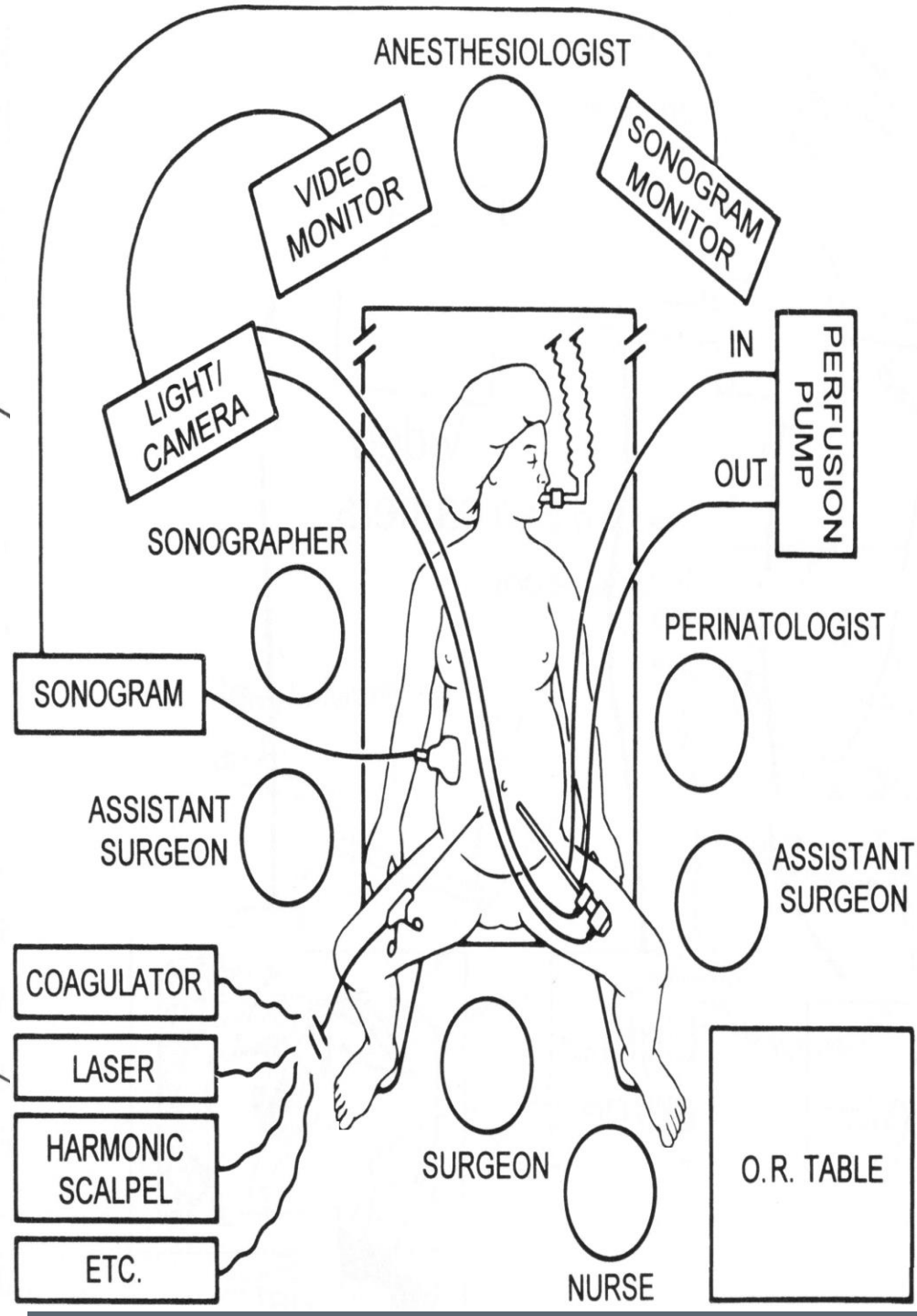
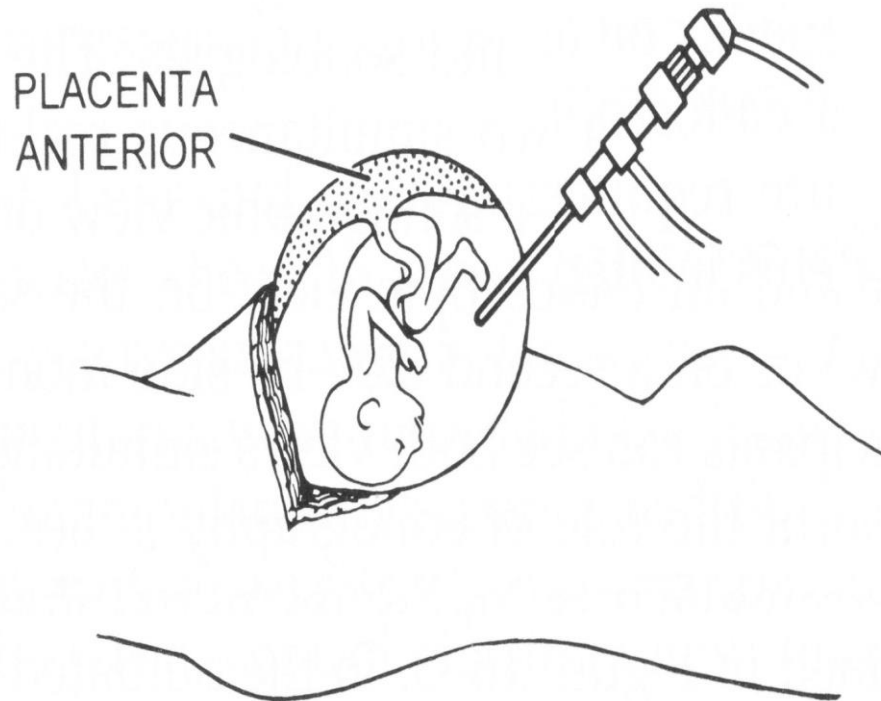
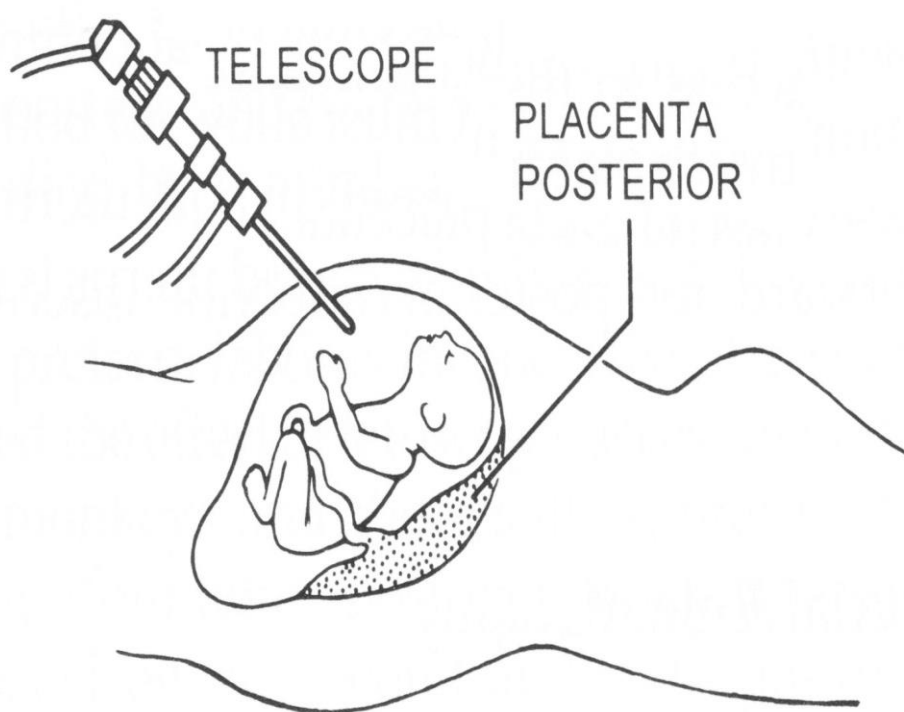
- close pregnancy monitoring and medications to control preterm labor may still be necessary
- requires a skilled team of expert

Uterus irrigated with NS – absorbed to peritoneum through fallopian tubes – **pulmonary oedema** as mother also receives tocolytics

FETENDO - fetal endoscopic

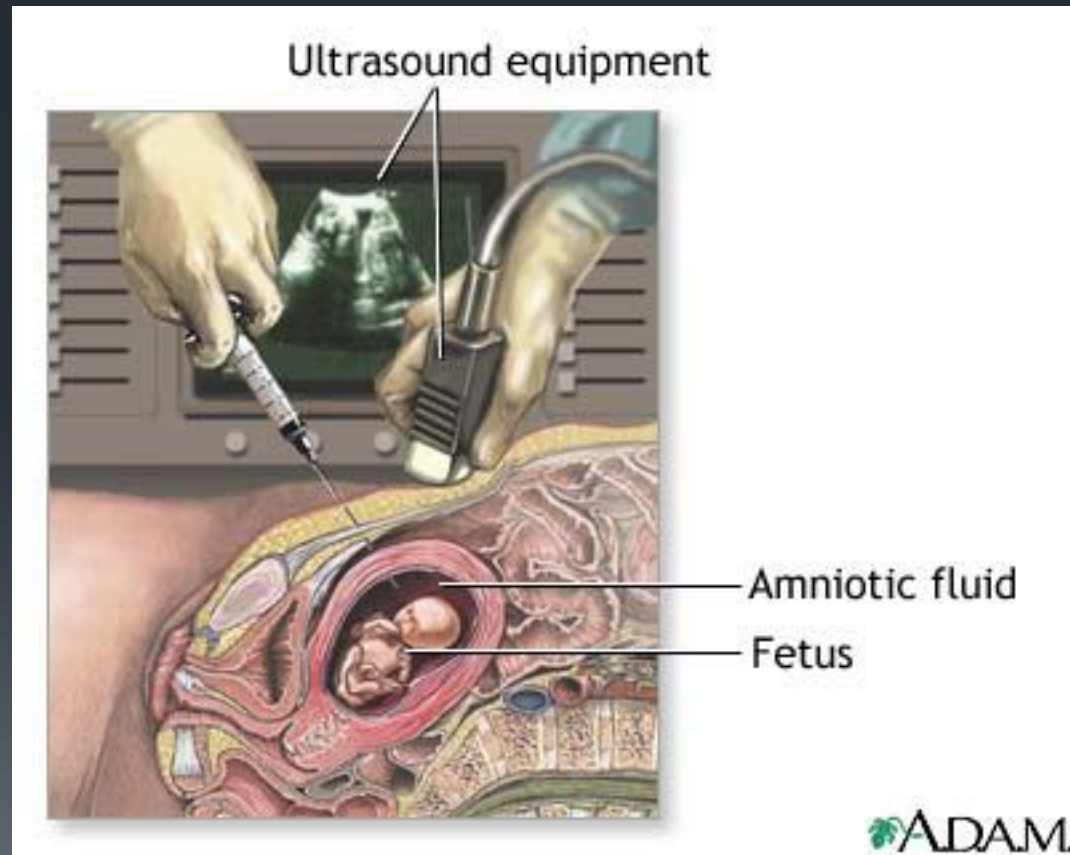
Fetoscopic access to the fetus
During or after the 18th week of pregnancy
Useful for treating placental problems
Technically difficult
Maintains fetal position

- ✓ Under **LA** with infiltration of both skin and peritoneum+/-sedation
[L]
[SEP]
- ✓ Under epidural, spinal or **CSE** anaesthesia [L]
[SEP]
- ✓ **High risk for urgent C-section:** CSE preferred [L]
[SEP]
- ✓ Sedation required for maternal **anxiolysis**



Types of fetal surgery

FIGS - Fetal image guided surgery



- ✓ for *amniocentesis*
- ✓ fetal blood sampling
- ✓ placement of *catheter-shunts* in the bladder, abdomen, or chest,
- ✓ *radiofrequency ablation* to solve problems with anomalous twins
- ✓ radiofrequency ablation for **some fetal cardiac defects** the fetus can be treated non-invasively *through the mother's circulation*

“yes....BUT!”

- ✓ not useful *for serious structural* problems that require surgery

- ✓ method of manipulating the fetus without either an uterus incision, or an endoscopic view
- ✓ *percutaneous* or, in some circumstances, *mini-laparotomy*
- ✓ **MAC**, under **a regional anesthesia**, or even under **local anesthesia**
- ✓ *the least invasive* of the fetal techniques
- ✓ **the least problems** for the mother in terms of hospitalization and discomfort
- ✓ preterm labor is also minimized

Types of fetal surgery

EXIT - Ex - utero intrapartum treatment procedure



Ex-utero intrapartum treatment (EXIT) procedure

Also known as OOPS - **operation on placental support**

Intervention occurring at the time of delivery

Used in cases where baby's airway requires surgical intervention

Provide the baby with patent airway that can provide oxygen to the lungs after separation of placenta

Starts as a routine LSCS but under **GA with maximum volatile agent (>2 MAC)**

Head of the baby is delivered, but placenta is in situ

Baby gets oxygen from placenta via umbilical cord

Considerations during EXIT procedure

Uterus needs to stay relaxed to permit placental perfusion

Uterus needs to contract at end to limit bleeding

Needs hemostatic hysterotomy

May permit upto 2 hours of ongoing placental perfusion

Challenges before the field of fetal surgery



- ✓ Ethical dilemma
- ✓ Maternal risk
- ✓ Fetal risk
- ✓ Maternal anaesthesia
- ✓ Fetal anaesthesia
- ✓ Post surgical tocolysis

What is the risk to the mother?

- all fetal intervention is the effect on the mother
- varies with the type of fetal procedure

For **open** surgery risk

- of general anesthesia
- of the abdominal incision
- of the incision in the uterus itself

Fetendo procedures is less because the procedure is less invasive

- the membranes lining the inside of the uterus remains a problem

The risk of **FIGS** is less than either Fetendo or open fetal surgery.

- without the incision in the maternal abdomen
- entering the uterus
- potential leakage of amniotic fluid
- separation of membranes
- preterm labor

Counselling of families:

- ✓ Potential fetal benefit
- ✓ Maternal risks
- ✓ Standard alternatives

Assessment of mother for anaesthesia

- ✓ h/o uterine activity
- ✓ airway examination
- ✓ concurrent medical problems

Assessment of fetus

Detailed USG to rule out other malformations

Fetal echocardiography

Fetal MRI

3D and 4D examination

Detail examination of affected organ system

Amniocentesis

Localisation of placenta and umbilical cord

Volume of amniotic fluid

Pre - operative preparation

- ✓ **Consent for caesarean delivery**
- ✓ **Maternal blood cross matched**
- ✓ **Availability of O-negative**
- ✓ **Adequate aspiration prophylaxis- sodium citrate orally and metoclopramide i.v.**
- ✓ **Indomethacin rectal suppository for postoperative tocolysis**
- ✓ **Epidural catheter- postoperative pain control**
- ✓ **Operating room is warmed to 26° C**

Adequate analgesia



Local anaesthesia

- 0.5 ml 1% lidocaine
- infiltration of both skin and peritoneum

Field block (TAP, RA)

CSE

Prevention and treatment of preterm labour

Tocolytic agents

- ✓ beta adrenergic agonists
- ✓ indomethacin (rectal)
- ✓ magnesium sulfate
- ✓ terbutaline (subcutaneous)
- ✓ Nitroglycerine (20µg/kg/min)

Halogenated agents-halothane, isoflurane, sevoflurane

Vascular stasis during hysterotomy - special stapling device

Postoperative pain control - epidural catheter

Anaesthetic techniques



Maternal sedation and local anaesthesia
Local anaesthesia with foetal paralysis
Regional anaesthesia
General anaesthesia

Maternal sedation and local anaesthesia

Indicated in percutaneous needle aspirations or catheter insertions
Drug of choice - BZD, narcotics for maternal anxiety

Disadvantages:

- ✓ increased hypoxia
- ✓ unprotected airway; aspiration risk
- ✓ presence of foetal movements

Close *monitoring for 3-4 hrs* required

Local anaesthesia with fetal paralysis

Indicated in fetal umbilical vein blood sampling

For fetal paralysis, NMB given via umbilical vein or intramuscularly
into fetal thigh or shoulder (vecuronium 0,1-0,3 mg/kg)

Advantages :

Loss of fetal movements for 2-4 hrs without any danger of maternal NMB

Disadvantages :

If fetus requires an emergency delivery, NMB will produce paralysed fetus and will require *respiratory assistance*

Regional anaesthesia

Indicated in MAFS (Minimal access fetal surgery)

Lumbar epidural, spinal or CSE anaesthesia

Advantages:

- excellent analgesia and good muscle relaxation
- avoid GA
- keeps mother awake and alert
- minimal effects on fetal hemodynamics, **uteroplacental blood flow and uterine activity**

Disadvantages:

- hypotension
- lack of fetal anaesthesia
- difficulty manipulating uterus and cord while the fetus may be moving

General anaesthesia

- ✓ aspiration prophylaxis - sodium citrate, ranitidine, metoclopramide
- ✓ prevention of supine hypotensive syndrome-left lateral tilt
- ✓ short acting amnestic
- ✓ short acting muscle relaxant-succinylcholine for RSI
- ✓ maintenance - 100% O₂
 - 50% O₂ and 50% N₂O with low inhalational +++
- ✓ maternal and fetal monitoring

General anaesthesia

- ✓ uterus opened similar to LSCS
- ✓ fetal part is exteriorized
- ✓ special stapling device
- ✓ surgical repair of fetus
- ✓ warmed Ringer Lactate along with antibiotics infused to replace amniotic fluid
- ✓ at the time of closure, i.v. MgSO₄ 6 gm over 20 minutes
- ✓ coughing or straining avoided to maintain integrity of uterine closure

Advantages:

- ✓ profound *uterine relaxation*
- ✓ allowing *uterine manipulation* with an immobile anaesthetised fetus

Disadvantages:

- ✓ fetal cardiac depression
- ✓ decreased uteroplacental blood flow

Postsurgical tocolysis

- ✓ high risk of preterm labour [SEP]
- ✓ pre-operative: rectal indomethacin [SEP]
- ✓ **MgSO₄** is tocolytic of choice and maintained for 2-3 days-**3 gm/hr infusion** [SEP]
- ✓ adequate maternal analgesia as maternal pain
- ✓ **epidural analgesia (PCEA) for 24-48 hrs** is recommended to prevent uterine contractility

Fetal monitoring

Maternal monitoring

- Pulse oximeter
- ECG
- HR
- BP monitoring
- Capnography
- Temperature

- ✓ Blood gas, pH, pO₂
- ✓ Blood glucose
- ✓ Electrolytes
- ✓ Fetal Hb from cord blood
- ✓ Electronic measurements of foetal heart rate, blood pressure and umbilical blood flow
- ✓ Foetal heart rate cardiotachometer-FHR, temperature
- ✓ Foetal ECG
- ✓ Foetal echocardiography

- ✓ Plethysmography and miniature pulse oximetry
- ✓ Periodic sonography- quality of foetal cardiac contractility, HR
- ✓ Direct uterine palpation - degree of uterine distension
- ✓ Irrigating solution is warmed to 37-38°C and monitored
- ✓ During fetoscopic placental vessel surgery, fetal i.v. and/or arterial line allows fetal blood sampling, pressure monitoring, administration of blood products, iv fluids and drugs

Fetal anaesthetic considerations

- ✓ Fetal organ systems are **immature**
- ✓ Fetal **cardiac output** is sensitive to HR changes
- ✓ Fetus has high vagal tone and thus response to stress with precipitous **bradycardia**
- ✓ Fetal circulatory blood volume is low, hence little intra-operative bleeding can cause **hypovolemia**, so trigger for transfusion is low
- ✓ During prolonged surgery, fetus need to be transfused **O-negative blood**

Fetal anaesthetic considerations

- ✓ Fetus tend to lose heat much easily from the exposed skin resulting in **hypothermia**
- ✓ Hypothermia can be minimized by limiting fetal surgical time and use of **warm irrigating fluids** (37-38°C)
- ✓ Immature coagulation system predispose to **bleeding** and difficulty in hemostasis
- ✓ Autonomic nervous and **adrenergic system** are immature
- ✓ **Placental transfer of anaesthetic agents** is a desirable effect of maternal anaesthesia

Fetal anaesthetic considerations

- ✓ Although **inhaled anaesthetics rapidly crosses the placenta**, fetal levels remain below maternal levels for a prolonged period of time
- ✓ Maternal anaesthesia **depresses fetal myocardium** and circulation-hypotension, bradycardia, cardiac collapse
- ✓ Maintenance of **uteroplacental circulation** is vital for successful outcome of the procedure
- ✓ Since uteroplacental flow is influenced by vascular resistance, therefore **uterus must remain relaxed**

Fetal anaesthetic considerations

- ✓ Kinking of umbilical cord avoided
- ✓ Normal **fetal arterial oxygen saturation is 60-70%** and aim is to maintain it above 40%
- ✓ Intra-operative **fetal distress** is manifested by **bradycardia**, decreased fetal oxygen saturation and **reduced cardiac output**
- ✓ Maternal hyperventilation is avoided as maternal hypocapnia causes **fetal placental vasoconstriction** and **fetal hypoxia**



⋮

Is fetus able to feel pain?

⋮

⋮

⋮

Fetal pain

- Not possible to **assess** fetal pain directly
- **Assessed indirectly** by ability of fetus to mount a stress response to noxious stimulus-increased fetal cortisol, beta-endorphins and central sparing hemodynamic changes
- Fetal administration of narcotic inhibits cortisol and beta-endorphin release but does not inhibit central sparing hemodynamic changes
- Fetal stress to **pain starts in 8** weeks gestation age



Ginekol Pol. 2011 Feb;82 (2) :133-6.

What Is Pain?

Is fetus able to feel pain?
Pain is a subjective sensory and emotional experience that requires the presence of consciousness to permit recognition of a stimulus as unpleasant.

Article in Polish

Kosińska-Kaczyńska K1, Wielgoś M.

Abstract

On the basis of fetal hormonal and hemodynamic responses to pain related stimuli, neuroanatomy and observations of preterm babies, it was concluded that human fetus is able **to feel pain after 24 weeks** gestation.

However it is possible that the fetus may feel pain even before that time. With the development of intrauterine diagnostic and therapeutic procedures, it is crucial to provide fetuses undergoing painful procedures not only with anesthesia but also analgesia. The article presents fetal pain research history and its implications for medicine.

Table. Anatomical and Functional Development of Nociception and Pain Perception Pathways

Anatomical/ Functional Characteristic	Description	Gestational Age, wk	Source
Peripheral cutaneous sensory receptors	Perioral cutaneous sensory receptors	7.5	Humphrey, ¹³ 1964
	Palmar cutaneous sensory receptors	10-10.5	
	Abdominal cutaneous sensory receptors	15	
Spinal cord	Spinal reflex arc in response to nonnoxious stimuli	8	Okado and Kojima, ¹⁴ 1984
	Neurons for nociception in dorsal root ganglion	19	Konstantinidou et al, ¹⁵ 1995
Thalamic afferents	Thalamic afferents reach subplate zone	20-22	Kostovic and Rakic, ¹⁶ 1990 Hevner, ¹⁷ 2000
	Thalamic afferents reach cortical plate	23-24	Kostovic and Rakic, ¹⁸ 1984 Kostovic and Goldman-Rakic, ¹⁹ 1983
Cortical function*	Somatosensory evoked potentials with distinct, constant components	29	Klimach and Cooke, ²⁰ 1988 Hrbek et al, ²¹ 1973
	First electrocardiographic pattern denoting both wakefulness and active sleep	30	Clancy et al, ²² 2003 Torres and Anderson, ²³ 1985

*Earliest evidence of functional thalamocortical connections required for conscious perception of pain.

Fetal analgesia

- General anaesthesia (volatil agents) \pm fetal i.m injection
- Remifentanyl (continuous infusion $0,1\mu\text{g/kg/min}$) mo.
- Opioid, Atropine, NMB i.m or into umbilical cord (Fentanyl $10\text{-}20\mu\text{g/kg}$)

New researches

Remifentanyl produces improved fetal immobilization with good maternal sedation and only minimal effects on maternal respiration (AnesthAnalg, 2005)

Continuous fentanyl infusion with midazolam provides acceptable maternal analgesia and sedation during fetoscopy(Masui, 2008)



Murdermese