

Anesthetic Considerations for Fetal Surgery

Assay
Protocol Submitted for Fulfillment
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List of Abbreviation

CCAM	: Congenital Cystic Adenoid Malformation
CDH	: Congenital Diaphragmatic Hernia
CHAOS	: Congenital High Airway Obstruction Syndrome
CHOP	: Children's Hospital of Philadelphia
EXIT	: Ex utero Intrapartum Treatment
FETO	: Fetoscopic Endoluminal Tracheal Occlusion
FIGS-IT	: Fetal Image Guided Surgery for Intervention or Therapy
FRC	: Functional Residual Capacity
GFR	: Glomerular Filtration Rate
HIFU	: High-Intensity Focused Ultrasound
IFMSS	: International fetal Medicine and Surgery Society
IUHCT	: In-utero Hematopoietic stem cell Transplantation
IUT	: Intra Uterine Transfusion
LES	: Lower Esophageal Sphincter
MAC	: Minimal Alveolar Concentration

MMC : Myelomeningocele

MOMS : Management of Myelomeningocele Study

NAFTNet : North American Fetal Therapy Network

NIH : National Institutes of Health

PLUG : Plug the Lung Until it Grows

SCT : Sacro Coccygeal Teratoma

TO : Tracheal Occlusion

TRAP : Twin Reversed Arterial Perfusion

TTTS : Twin-Twin Transfusion Syndrome

UCSF : University of California San Francisco

XSCID : X-linked Severe Combined Immunosufficiency
Disease

Abstract

The anesthetist is part of a multidisciplinary team which allows understanding of the pathogenesis of the fetal conditions and how the planned therapy may influence outcome. Two expert anesthetists should be present one for the mother and another for her baby. It is assumed that the anesthetists are familiar with routine obstetric anaesthetic considerations and those relevant to the fetal surgery were highlighted. It is essential to have good communication and cooperation between surgeons, anesthesiologists and perinatal physicians. This communication will allow development of a cohesive anesthetic and surgical plan that can be used for the safe perioperative management of the fetal surgery patient.

Postoperative management include proper tocolysis in midgestational surgeries to prevent uterine contraction and allow proper uteroplacental circulation. In contrast to that, reversal of tocolysis to prevent uterine relaxation and prevent postpartum heamorrhage should be done in EXIT procedure. Intensive care facilities for both mother and neonate must be available. Another operating room maybe needed for further neonatal surgery according to fetal anomaly.

A lot of complications may meet the anesthetists working in fetal surgery for both mother and fetus including maternal heamorrhage, preterm labor, maternal pulmonary oedema, maternal and fetal cardiovascular depression and death of one or both of them.

Key word

Considerations

HISTORY OF FETAL SURGERY

CDH

FIGS-IT

CHAPTER I

HISTORY OF FETAL SURGERY

Over the past 3 decades fetal surgery for congenital disease has evolved from merely a fanciful concept to a medical field in its own right⁽⁸⁾ first in animal models and subsequently in humans.

At the same time, major advances in fetal imaging and diagnosis, anesthesia, and tocolysis have allowed fetal intervention to become a vital tool for patients who would suffer from significant morbidity and mortality. This chapter offers a concise overview of the history of fetal surgery, from its early days to its current status as an important means for the early treatment of potentially disturbing congenital anomalies.

Experimental Fetal Surgery

In the 1930s and 1940s, experimental fetal observation gained momentum⁽⁸⁾. The most productive fetal experimental model was operations on the lamb fetus using spinal anesthesia. Surgery was performed through a small uterine incision, without removing the fetus. Hall's work on development of the nervous system in the fetal rat and Barron's work on neurologic development in the fetal lamb extended the techniques for fetal surgery, including the use of pursestring sutures to avoid the loss of amniotic fluid

In the 1950s, Louw and Barnard produced intestinal atresia, similar to that seen in human neonates, by interrupting the mesenteric blood supply in fetal puppies⁽⁹⁾. This contribution was important because it not only

established the ischemic pathogenesis of neonatal intestinal atresia but also demonstrated the feasibility of simulating human birth defects by appropriate fetal manipulation

In the 1960s and 1970s, experimental fetal surgery was used to simulate various human congenital anomalies: coarctation of the aorta in the puppy, congenital diaphragmatic hernia in the lamb⁽⁹⁾ congenital hydronephrosis in the rabbit and lamb and congenital heart disease in the lamb. The development of a chronically catheterized fetal lamb preparation led to intensive investigation of fetal cardiovascular, pulmonary, and renal physiology⁽⁸⁾.

Experimental fetal surgery proved to be more difficult in the primate, where uterine contractility and preterm labor were more difficult to control.⁽⁸⁾ During the last 2 decades, however, advances in surgical and anesthetic techniques and in the pharmacologic control of labor have made experimental manipulation of even the primate fetus feasible

By the late 1970s, various experimental fetal models were being used widely in the study of normal developmental physiology and the pathophysiology of several congenital defects⁽¹⁰⁾. These models proved to be both descriptive and predictive. For example, removal of a piece of diaphragm in the fetal lamb not only produced a lesion that mimicked the human disease analog of congenital diaphragmatic hernia (CDH), but also produced the associated developmental consequence (i.e. pulmonary hypoplasia); the model has been used successfully to explore various types of fetal intervention aimed at reversing pulmonary hypoplasia: total repair in

utero, maternal steroid treatment, and tracheal occlusion with clips and then removable balloons.

By 1980, The focus of this experimentation occurred at the University of California, San Francisco (UCSF) where the right environment of multispecialty cooperation enabled productive study⁽⁸⁾. Congenital hydronephrosis, diaphragmatic hernia, and obstructive hydrocephalus are examples of malformations in which a simple anatomic lesion interferes with organ development and, if the anatomic defect is corrected, fetal development may proceed normally. Proof of concept in animal models was gradually followed by attempts at therapy for affected human pregnancies

Development of Fetal Intervention in Humans

A) Development of Diagnosis of Fetal Anomalies:

Before the human fetal surgery became a realistic possibility and the concept was able to move from the laboratory to the operating room, significant advances in imaging, assessment, and monitoring of the fetus were first necessary⁽⁸⁾. Fetal activity felt by the mother or palpated by her physician was the first crude measure of fetal well-being. Then the fetal heartbeat, detected at first by auscultation and later by sophisticated electronic monitors, was found to reflect fetal stress and distress. Later, minute amounts of gestational hormones were detected in maternal blood and urine. These levels correlated with the condition of the fetus, later came amniocentesis as a technique to evaluate fetal health by cytogenetic and

biochemical analysis of the constituents of amniotic fluid made possible the prenatal diagnosis of many inherited metabolic and chromosomal disorders.

Maternal serum alpha-fetoprotein screening has increased the ability to detect some anomalies that might not otherwise have been detected⁽⁹⁾. The combination ultrasonography with maternal serum alpha-fetoprotein screening allows for prenatal diagnosis of anomalies of the fetal neural tube, abdominal wall, urinary system, or the lymphatic system (i.e cystic hygroma) Sonography was then developed. This method enabled accurate description of normal and abnormal fetal anatomy with considerable detail and, later on, provided “live” moving pictures.

Radiographs were recognized as being potentially harmful to the developing organism⁽⁸⁾. Plain radiographs yielded little information, and introduction of radiopaque materials into the amniotic fluid (amniogram) increased the risk for premature rupture of the membranes or preterm labor without yielding much more diagnostic information. Unlike previous techniques, ultrasonic imaging seems to have no harmful effect on the mother or on the fetus. With prenatal ultrasound, the sonographer can make sophisticated observations of the developing heart and its valves. Fetal parts can be measured to assess fetal growth, and an increasing number of anatomic malformations can be accurately delineated. Sonography can be used to guide needle punctures of the amniotic cavity for amniocentesis, or needle aspiration of fetal urine, ascites, and cerebrospinal fluid. Real-time sonography can guide fetal endoscopic surgery and ensure the safe acquisition of fetal blood and other fetal tissues for biopsy (e.g skin, liver,