Minimally Invasive Fetal Surgery

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KEYWORDS

- Fetal surgery • Fetal therapy • Fetal diagnosis • Prenatal diagnosis
- Fetoscopic surgery • Fetoscopy

KEY POINTS

- The goal of minimally invasive fetal treatments is to decrease maternal risk and premature rupture of membranes.
- Real-time ultrasound imaging is crucial to the implementation and success of minimally invasive fetal procedures.
- Multidisciplinary fetal procedural teams, including a fetal surgeon, ultrasonographer, perinatologist, and anesthesiologist, are critical to the delivery of quality care.

INTRODUCTION: NATURE OF THE PROBLEM
History and General Principles

In the past 50 years, fetal therapy has progressed from mere concept to an accepted and viable treatment modality. A better understanding of embryology and fetal development, coupled with the advent of high-resolution noninvasive fetal imaging, led to a fundamental shift in thinking of the fetus itself as a patient.[1] With earlier and more accurate diagnosis of many congenital defects, the window of opportunity for intervention widened. Throughout the second half of the 20th century, physician and surgeon scientists took a rigorous scientific approach in tackling the problem of fetal surgery: identifying the clinical need, studying the natural history of diseases in the human fetus, understanding the pathophysiology and proposed treatments in the laboratory, and safely implementing fetal interventions in humans. Through these efforts, fetal therapy has improved survival and decreased morbidity for many devastating congenital defects, while minimizing risk to the mother. Technical advances, coupled with

ongoing efforts to make fetal procedures safer for the mother, have led to ongoing innovation in the field, including the development of minimally invasive therapies and procedures.

Although many minimally invasive fetal operations are simply adaptations of the open operation, others were developed specifically for minimally invasive techniques. Indeed, some can only be performed in this way. The first modern fetal intervention was needle based. In 1963, Liley performed the first fetal transfusion by inserting a 16-G Touhy needle into the fetal peritoneal space.[2] In this era before modern ultrasound imaging, Liley localized the fetal abdomen by injecting contrast into the amniotic cavity and allowing it to be swallowed by the fetus to opacify the fetal bowel. Given the success of this needle-based technique, enthusiasm for existing open transfusion procedures waned.[3] In the 1970s, direct visualization of the fetus with endoscopy was first introduced for diagnostic purposes, such as to obtain fetal blood or biopsy tissue, but therapeutic use was limited because of its invasiveness and the technical skill required.[4] Fetoscopic diagnosis became essentially obsolete when ultrasound examination became more widespread, shifting instead to percutaneous needle-based techniques under ultrasound guidance. It was not until the early 1990s, when smaller cameras and endoscopes coupled with the increasing popularity of laparoscopic surgery, led to a resurgence of interest in fetoscopic and minimal access procedures.[4–7] Box 1 highlights some milestones in the development of minimally invasive fetal procedures. Some of the early challenges in the development of these techniques have been summarized elsewhere.[8]

Ethical Considerations

Fetal intervention raises unique ethical issues surrounding maternal autonomy and decision making. Although the goal of fetal intervention is to cure or better the health of the fetus, any intervention, whether surgical or pharmacologic, necessarily affects the pregnant mother. The pregnant woman gains nothing in terms of personal health benefits, and the unborn child gets all potential benefit. Protecting the pregnant woman and mitigating risk is the greatest responsibility of fetal therapy teams. Therefore, explicit informed consent is required for all fetal interventions, and must be obtained with a comprehensive discussion of her unique risks. Moreover, women must also be informed of, and provided access to, alternatives to intervention, including postnatal therapy, palliative care, or pregnancy termination in a nondirective manner.[9,10]

Innovation in fetal therapy, including the development of minimally invasive procedures, is necessary to continue to expand the benefits of fetal treatment and reduce risks to pregnant women. However, formal clinical research in this population is often

Box 1	
Milestones in the development of minimally invasive fetal surgery	
Milestone	**Year**
First fetal transfusion	1963
First fetal vesicoamniotic shunt placement	1982
First open fetal surgery	1982
First fetal thoracoamniotic shunt placement	1987
First laser ablation for twin–twin transfusion syndrome	1990
First fetoscopic repair of myelomeningocele	1997
First "Fetendo" tracheal clipping for congenital diaphragmatic hernia	1997
First fetoscopic release of amniotic band	1997
First fetoscopic balloon tracheal occlusion for congenital diaphragmatic hernia	2001