REVIEW ARTICLE

Current Status of Minimal Access Surgery (MAS) in the Field of Maternal-Fetal Medicine

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Abstract

Minimal access surgery has had resounding impact in the practice of surgery. The advantages include less scarring, quick recovery and return to work. It is not surprising that this field has received attention in the practice of fetal surgery as clinicians were faced with considerable complications inherent in open surgical procedures. The field has evolved, skills refined and technology improved, allowing management of selected fetal conditions through minimal access into the uterine cavity and the fetus. There is however, challenges that needs to be addressed. Open surgery cannot be relegated to history books at this stage and the two approaches have specific indications and are complementary.

Keywords: Laparoscopy in pregnancy, MAS in fetal medicine, maternal fetal medicine and laparoscopy.

INTRODUCTION

Advances in medical imaging have led to an improvement in prenatal diagnosis of congenital anomalies. This has been made possible through the incorporation of new ultrasound technologies, use of doppler and real time imaging. These have resulted in improvement in resolution and quality of ultrasound images. Concurrent use l Magnetic Resonance Imaging (MRI) in fetal imaging has resulted in better definition of pathology and diagnosis in situation where ultrasound imaging turns to be inconclusive.[1] Together with the accolades gained by medical science in the understanding of the pathophysiological basis of diseases, clinicians have never been better equipped in making accurate diagnosis and better positioned in counselling their patients regarding prognosis and options available for the fetal condition in question, as is the case now.

Sir William Albert Liley is regarded as the 'father of fetal medicine'. His successful intrauterine transfusion of fetus affected by Rhesus disease in New Zealand, in 1963, opened a multitude of possibilities and opportunities for fetal medicine specialists.[2,3] This has been followed by different developments, animal studies and refining of skills. The Fetal treatment center at the University of California, San Francisco (UCSF), under the leadership of Michael Harrison (a pediatric surgeon by training), has been at the forefront of this development.[4] This center has been in limelight for performing fetal open fetal surgery and later inversion of minimal fetal approach dubbed 'FETENDO' (use of small instruments and manipulating them inside the uterine cavity was viewed as similar to playing video games, hence the name). Other groups like the children's hospital of Philadelphia (CHOP), and the fetal center at Leuven, etc joined suite.[2] There are now few specialized centers in different countries dedicated to this cause. The end result has been research and refinement of skills as new knowledge is acquired.[4-6] The observation that postnatal therapy was not the answer to all fetuses, has led to the emergence of fetal surgery over the last 30 years. The vision has been an attempt to salvage the few fetuses with conditions that are known to result in stillbirth if left untreated, arrest the pathophysiological process or reverse fetal damage that is not amenable to postnatal correction. Currently three approaches are available for intrauterine management of fetal conditions, open approach via hysterotomy or minimal access using endoscopy or Fetal Image Guided Surgery (FIGS).[6] The latter approach is what is generally referred to as percutaneous approach. This procedure uses needles to access the fetus under ultrasound guidance. Fetal surgery has undergone evolution from the first successful intrauterine transfusion in New Zealand, hysterotomy for vascular access and intrauterine transfusion (Puerto Rico, 1964), diagnostic fetoscopy (Yale, 1974), Laser ablation of placental vessels (Milwaukee, London,1995) right to the use of amniotic collagen plug (Leuven, 2007) and sclero-therapy for congenital cystic adenomatous malformation (CCAM) performed in Venezuela in 2007. A comprehensive review of these milestones is well articulated in the article by Jancelewicz and Harrison.[2]

The critical point determining success for fetal surgery is a multidisciplinary approach. This itself has led to the current advances in management as each discipline constantly strive to excel in their field with audit as the key factors in reaching new frontiers. The International Fetal Medicine and Surgery Society, has endorsed a consensus statement aimed at guiding the practice of fetal surgery (Table 1).[7]

With the practice of open surgery considerable fetal and maternal morbidity were encountered. This has been the driving force behind the birth of minimal access techniques as clinicians tried to balance the benefit and side effect of intervention. Major drawback of open access was has been preterm labor, preterm rupture of membrane and chorioamnionitis, although there has been notable success.

Minimal access surgery is a well-established surgical approach, often regarded as the preferred method if not gold standard for some form of surgical treatment such as in some general surgical conditions and the elderly.[8,9] Advantages of this technique have been described elsewhere for different kinds of surgical setting.[8,9] The question arises as to the status of minimal access surgery in the current management of fetal conditions given its established role in other forms of surgery. The above question has prompted this literature review.

AIM

The aim of this article was to review the role of minimal access surgery in the management of fetal conditions as published in the literature.

MATERIALS AND METHODS

Literature search was performed using Highwire, Medscape, Medline and google scholar. Keywords used for the search were as follows:

Fetal surgery, Fetoscopy, Minimal access surgery.

Articles were considered in terms of the year of publication, relevance to the topic, publishing/research institution and number of cases where an original research was undertaken. Older articles were considered where the author felt that they carried information that was indispensable for the completion of this review.

Table 1: Prerequisites for fetal surgery

1. There should be accurate diagnosis, exclusion of associated anomalies and proper staging of the condition.
2. The natural history and prognosis for the given condition should have been established.
3. Absence of effective postnatal treatment.
4. Animal studies performed *in utero* have demonstrated feasibility and effectiveness of the proposed therapy.
5. The intervention should take place in specialized setting, with multidisciplinary involvement. These centers should have strict protocols and institutional ethics committee approval with informed consent for the affected parents.

Adapted from Deprest et al[7], 2006

RESULTS

The findings of the literature search are discussed under different subheadings below.

Ethical Consideration

Intrauterine surgical procedures are fraught with ethical dilemmas. The experimental nature of the procedures and the maternal-fetal conflicts are issues that need consideration. Surgery in the fetus is effectively surgery on the mother who is always an innocent bystander with no direct benefit as far as her well-being is concerned. Risks of anesthesia and surgery to both mother and fetus should be addressed and the woman counselled appropriately to obtain informed consent. The concept of the fetal patient and the boundaries that define this status is often blurred. However, once the woman confer patient status to her unborn baby, the beneficence-based obligations of the clinician to the fetal patient should be weighed against autonomy considerations for the pregnant mother.[10] Possible outcomes and effect on pregnancy, alternative form of treatment and effect of the proposed intervention on her future should be discussed and recommendation from the International Society of Fetal Medicine and Surgery (Table 1), adhered to.

A multidisciplinary team of experts came together at the National Institutes of Health (NHI) in the year 2000 with further recommendations.[11] The principle of redistribution of resources is another ethical issue that need a review on its own when it comes to fetal surgery. Some may argue against the use of limited resources in a world burdened with vast and potentially preventable conditions, for procedures that are best regarded as experimental with questionable long-term effects to the recipients (fetuses). Long-term data is needed to assess the effect that these procedures will have during adulthood to the index patient.

Technical Aspects

Instruments used in fetal endoscopic surgery are purpose-designed. This has come as a result of cooperation between companies and clinicians. Entry into amniotic cavity is by diamond-cut needle within sheath. This has been designed to minimize rupture of membrane and is expandable. Troncars are miniaturised and endoscopes are usually 18 cm in length, 1.2 to 3.5 mm in size.[5] Thirty telescopes offer

maximum visibility in the amniotic cavity but zero degrees are available. Flexible cannulas and telescopes using fiberoptic technology are also available for placental operations.[5]

Carbon dioxide is the gas used for adults endoscopy as it makes visualization easy, is well-absorbed and does not support combustion. This has been shown to result in fetal acidosis and placental insufficiency, when used in fetal surgery.[12,13] Because ultrasound is needed to aid in troncar insertion and fetal monitoring, sonographic images would be compromised by use of carbon dioxide.[5] A fluid exchange medium is often used.

Clinical Application

There are number of fetal conditions that minimal access surgery has been utilized successfully.

Twin to Twin Transfusion Syndrome (TTTS)

This is a complex condition occurring in 10 to 20% of monochorionic pregnancy.[5,14] The pathological basis for this condition is often unpaired vascular anastomoses between the twins. One twin, the donor, suffers from intrauterine growth restriction due to chronic vascular insufficiency and the other become fluid overloaded. There are various staging systems that are used in the management of TTTS, for example; Quintero, Cincinnati, Children's Hospital of Philadelphia (CHOP) and the Cardiovascular Profile Scoring system.[15] Mortality has been reported to be around 80% if untreated.[15]

Treatment options available include, amnioreduction, microseptostomy, fetoscopic laser photocoagulation, photoscopic cord coagulation. A randomized controlled trial comparing laser versus serial amnioreduction concluded that laser was superior to serial amnioreduction in the management of this condition before 26 weeks.[16] The study composed of 72 women for the laser group and 70 women for the amnioreduction group, reported higher likelihood of survival, lower incidence of periventricular leukomalcia and more less neurological complications at 6 months of age in favor of laser treatment. Other studies have reported similar findings.[17,18] The procedure is depicted in Figure 1.

Another option is fetoscopic reduction through cord occlusion/coagulation for the recipient twin with advanced cardiomyopathy and no chance of survival.[19] Advantages of these procedures are that they can be done under local/regional anesthesia or a combination thereof and the patient can be discharged the same day.

Long-term outcome of laser treatment has been studied. In a study of 189 children who underwent intrauterine photocoagulation with laser, Banet et al, reported normal development in 78% at 22 months, 11% minor neurological deficit (minor neurological abnormalities, e.g. mildly delayed motor development) while 11% had major neurological sequel such cerebral palsy.[21] These findings were similar to the one reported in the eurofetus (major abnormalities in 13%).[22] In his study, no difference was noted between the amnioreduction and laser-treated group. This underscores the inherent effect of the underlying condition as well as gestational age in treatment outcome not necessarily the form of treatment.[14] Laser, seem to be the best choice in the treatment of severe TTTS.

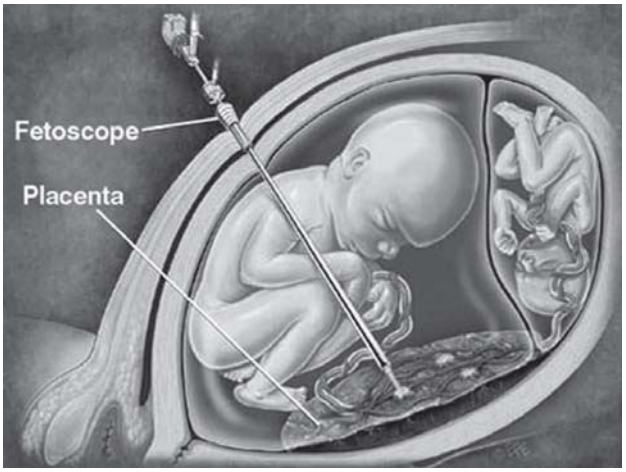

Fig. 1: Laser treatment of twin-to-twin transfusion syndrome (From Lambretti,[20] 2009)

Congenital Diaphragmatic Hernia (CDH)

This condition affects 1:2400 livebirths.[23] The underlying problem is an anatomical defect in the diaphragm leading to herniation of abdominal organs into the thorax. This results in lung compression, lung hypoplasia, hydrops and fetal demise. The condition ranges from mild to severe. Initial open approach to correct the defect was faced with serious technical challenges.[24,25] Negative prognostic factors for this condition that predict outcome is the presence/absence of liver herniation (liver up/liver down) and the lung-head ratio (LHR).[25,26]

Due to the discouraging results of open surgery, endoscopic fetal surgery evolved. Initial strategies using trancheal clips gave some hope, but clips resulted in laryngeal nerve damage and were difficult to remove.[27] The subsequent use of balloon and EXIT (Ex Utero Intrapartum Treatment) procedure retained the success of the procedure and overcame the problems with the clips.[28] Further research is ongoing.[23] This form of treatment seem to hold hope for the future.

Twin Reversed Arterial Perfusion (TRAP)

This is a rare condition (1:35000 livebirth)[5] characterized by perfusion imbalance as a results of vascular connection between an acardiac achephalic twin and a normal fetus.[29] Blood is pumped by the normal fetus to the 'monster'. Mortality, if untreated is between 50 and 75%.[5,29] Several therapeutic strategies including use of potassium chloride, amnioreduction, extracorporeal knot ligation of the cord, laser, monopolar and bipolar coagulation as well as ultrasonic transaction has been tried.[5,29-31] Although the numbers are not big and difficult to make comparison, laser, bipolar and ultrasonic transaction seems to be promising.

Fetal Tumors

Two common tumors that has been studied are the Sacroccocygeal teratoma (SCT) and congenital cystic adenomatoid of the lung (CCAM).[5] The problems with these tumors is that they may cause compression or lead to high-output cardia failure resulting in fetal death. Open surgery has been used to successfully excise the tumors but limited by complications. Percutaneous approach using radio-frequency ablation (RFA) for treatment of SCT has been reported but was associated with uncontrolled burns to adjacent tissues.[32,33] Open approach seem to offer better results for thoracic lesions and SCT when both are complicated by hydrops.[29]

Obstructive Uropathy

Urinary tract abnormalities constitute 50% of prenatal diagnosed fetal anomalies.[34] The major problem is obstruction leading to renal damage and lung hypoplasia secondary to oligohdramnios. Percutaneous vesicoamniotic shunts have been used with complication rate of 25% due to shunt displacement.[5] Other tried procedures include *in utero* percutaneous cystoscopy and ablation of posterior urethral valve.[35] Long-term results will clarify the value of these procedures.

Other Procedures

Minimal access surgery has been used for the release of amniotic band syndrome with the use of fetoscope. These bands are associated with limb constrictions and amputations as well as postural deformities. Other area that has received attention is the repair of cleft palate endoscopically with minimal or no scarring. Attempt to repair myelomeningocoele endoscopically has been described using carbon dioxide (amniotic fluid removed) and maternal skin craft as the patch material.[36] The results of open surgery for this procedure is yet to be challenged.[37] There is work reported in animals on fetoscopic management of aortic and pulmonary stenosis.

OVERALL COMPLICATIONS

While major complications of open surgery have been reduced by minimal invasive approach, preterm labor and PPROM remain challenge (Table 2).

Table 2: Maternal morbidity and mortality for 178 interventions at University of California, San Francisco with postoperative continuing pregnancy, divided into operative subgroups

	Open hysterotomy	*Endoscopy FETENDO/Laparatomy and FETENDO*	*Percutaneous FIGS/Laparatomy and FIGS*	*All interventions*
Patients with postoperative continuing pregnancy	79	68	31	178
Gestational age at surgery (wks)	25.1	24.5	21.1	24.2
Range (wks) delivery (wks)	17.6-30.4	17.9-32.1	17.0-26.6	17.0-32.1
Gestational age at delivery (wks)	30.1	30.4	32.7	30.7
Range (wks) Interval surgery to delivery (wks)	21.6-36.7 4.9	19.6-39.3 6.0	21.7-40.4 11.6	19.6-40.4 6.5
Range (wks)	0-16	0-19	0.3-21.4	0-21.4
Pulmonary edema	22/79 (27.8%)	17/68 (25.0%)	0/31 (0.0%)	39/178 (21.9%)
Bleeding requiring blood transfusion	11/87 (12.6%)	2/69 (2.9%)	0/31 (0.0%)	13/187 (7.0%)
PTL leading to delivery	26/79 (32.9%)	18/68 (26.5%)	4/31 (12.9%)	48/178 (27.0%)
PPROM	41/79 (51.9%)	30/68 (44.1%)	8/31 (25.8%)	79/178 (44.4%)
Chorioamnionitis	7/79 (8.9%)	1/68 (1.5%)	0/31 (0.0%)	8/178 (4.5%)

Table from Wu and Ball,[38] 2009.

CONCLUSION

Minimal Access Surgery (MAS) has had an impact in the practice of fetal medicine and surgery. It has specific indications and cannot replace open procedures but rather regarded complementary. As the field evolves, new insight gained fetal pathologies, skills, techniques and technology improve, one can only speculate that with time, this field will become more refined and this will translate to better outcomes for the fetal patients.

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