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Care Levels for Fetal Therapy Centers

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Abstract

Fetal therapies undertaken to improve fetal outcome or to optimize transition to neonate life often entail some level of maternal, fetal or neonatal risk. A fetal therapy center needs access to resources to carry out such therapies and to manage maternal, fetal or neonatal complications that might arise, either related to the therapy *per se* or as part of the underlying fetal or maternal condition. Accordingly, a fetal therapy center requires a dedicated operational infrastructure and necessary resources to allow for appropriate oversight, monitoring of clinical performance, and to facilitate multidisciplinary collaboration between the relevant specialties. Three care levels for fetal therapy centers are proposed in order to match the anticipated care complexity with appropriate resources to achieve an optimal outcome at an institutional and regional level. A level 1 fetal therapy center should be capable of offering fetal interventions that may be associated with obstetric risks of preterm birth or membrane rupture, but which would be very unlikely to require maternal medical subspecialty or intensive care, with neonatal risks not exceeding those of moderate prematurity. A level 2 center should have the incremental capacity to provide maternal intensive care and to manage extreme neonatal prematurity. A level 3 therapy center should offer the full range of fetal interventions (including open fetal surgery), and could manage any of the associated maternal complications and comorbidities, as well as have access to neonatal and pediatric surgical intervention including indicated surgery for neonates with congenital anomalies.

Precis:

Three care levels for fetal therapy centers are proposed based on the resources needed to carry out interventions and manage maternal, fetal, and neonatal risks.

INTRODUCTION

Fetal therapy, performed for the benefit of the fetus and neonate, has evolved markedly over the last three decades[1, 2]. This is reflected in the increasing membership of fetal therapy centers in the North American Fetal Therapy Network (NAFTNet), and by the number and complexity of interventions cumulatively performed at these centers[3, 4]. All fetal interventions, whether medical or surgical, are by definition performed on a pregnant individual before separation of the fetus from the placenta at birth. As such, they may entail maternal risks in either the current or future pregnancies, as well as fetal or neonatal risks. While this document refers to fetal interventions, recommendations are intended to prioritize safety for both the pregnant individual and their fetus or neonate based on the available evidence.

To perform any fetal intervention, provide all the associated care needs, address any potential risks and assess outcomes, a fetal therapy center requires a dedicated operational infrastructure, which encourages and facilitates the close collaboration of healthcare professionals (HCP) from maternal, fetal, nursing, anesthetic and pediatric specialties[5,6,7]. Several of these specialties, specifically obstetrics/maternal-fetal medicine (MFM), pediatric surgery and neonatology, already have established levels of care[8,9,10]. These are based on the guiding principle of matching resources with the anticipated complexity of care to achieve optimal outcomes at an institutional and regional level[8, 9, 10, 11]. These care levels are independently assigned for each of these specialties and may not coexist at the same level at a single institution. Guidelines issued by the American College of Obstetricians and

Gynecologists (ACOG) and the Society for Maternal-Fetal Medicine (SMFM), American Academy of Pediatrics (AAP) have outlined the general operational infrastructure necessary for centers to perform fetal diagnostic and therapeutic procedures, but have not stratified these guidelines by the risk profile of individual interventions.

GOAL

The purpose of this document is to propose levels of care for fetal therapy centers based on the anticipated complexity of an intervention for both pregnant individuals and their neonates. Our recommendations will also consider the obstetric, neonatal, pediatric (medical and surgical) and ethical care resources that should be in place to support such fetal interventions. Our guiding principle is to provide maternal safety and autonomy, while also addressing the anticipated care needs of the fetus and neonate.

FETAL INTERVENTIONS AND THE PRACTICE OF FETAL THERAPY

The goal of fetal therapy may be to achieve a prenatal cure, attenuate or improve sequelae for the infant, or optimize the transition to postnatal life. When presented with a prenatal diagnosis, a pregnant individual may choose to pursue expectant management, fetal therapy, pregnancy termination, active neonatal care or palliation[12, 13, 14, 15, 16, 17]. It is the duty of the fetal therapy center to support those decisions with the appropriate level of care, regardless of the management choice.

A fetal therapy center must provide a pregnant individual with an understanding of the fetal condition, and the relative maternal and fetal risks and benefits of any proposed intervention, when considering management options. The ability to appropriately counsel patients relies on diagnostic capabilities that enable an estimate of fetal risk based on an accurate prenatal diagnosis and an understanding of the natural history of the disease and its overall prognosis.

The risks of any fetal intervention l depends on the i) technical details of the procedure including its complexity, the fetal status, degree of compromise and gestational age, ii) presence of maternal comorbidities (e.g. high body mass index (BMI), obstetric risk factors for preterm birth or membrane rupture, and iii) operator and center's experience[18–27]. A comprehensive maternal assessment of psychosocial, familial, social, moral, religious, ethical and financial influences are elements to be considered in the planning of the patient's care[28, 29].

Risk-benefit assessment will differ according to the specific intervention, and by practitioner and fetal therapy center. If care can be better provided at another facility, referral should be considered.

Informed consent for fetal therapy is unique because interventions for the benefit of the fetus are performed on the pregnant individual. This emphasizes the need for a non-directive, shared decision-making approach that allows the pregnant individual to make an autonomous, intentional and voluntary choice, free of any coercion or undue influence from family members, spouses, partners or even HCP's themselves, to undergo or decline any fetal therapy. A thorough discussion with patients needs to clearly present the full range

of therapeutic options, their risks and benefits for the fetus, as well as any potential risks to the pregnant individual in the current or future pregnancies. An important, conversation that should precede any fetal intervention, particularly in a sick or very premature fetus, is the management of procedure-related fetal complications, specifically addressing whether delivery or non-intervention is to be undertaken, with clear discussion of all consequences. These conversations are best held in collaboration with MFM, neonatology and additional specialties as required by the condition and may benefit from the involvement of an unbiased and specially trained independent advocate, such as their primary HCP, perinatal nurse, or religious advisor[29–33].

UNIVERSAL CORE COMPONENTS AND OPERATIONAL RESPONSIBILITIES OF A FETAL THERAPY CENTER

Certain resources are fundamental to optimize the provision of care and to minimize any fetal therapy procedure-related risks. Universal core components of a fetal therapy center as designated by several professional societies are summarized in Box 1[2, 5, 7]. The need for additional resources, that may be required for specific interventions, should be considered in the context of the proposed fetal therapy center care levels.

I. Leadership

A fetal therapy center should have a medical director, a physician with experience in maternal and fetal care and specifically in maternal-fetal interventions. The medical director is responsible for operational oversight over the delivery of clinical care and ensuring patient safety. The medical director should work in partnership with a nursing director, who supervises the nursing staff and shares in the oversight of patient care and center operations. Others may be appointed in allied leadership roles, depending on the operational set-up at a particular fetal therapy center. While fetal therapy is not a recognized subspecialty, its practice demands advanced understanding and training in fetal physiology, expertise in prenatal diagnosis, fetal imaging and surveillance, and operative skills to safely perform fetal interventions.

II. Staffing

A fetal therapy center requires a multidisciplinary and closely collaborative group of healthcare personnel. In addition to providing safe and effective fetal therapy, a center's team should facilitate a positive care environment and experience by providing pregnant individuals and their families with access to resources that facilitate managing their expectations and coping with their stress and grief. Nurses with expertise in fetal diagnosis and prenatal care play a central role in fetal therapy centers and may be involved in the patients' and referring providers' initial contact with the center, throughout prenatal evaluation, counseling, fetal intervention and follow-up[33, 34]. A financial counselor or insurance specialist may assist in reviewing a patient's health care coverage and initiate insurance authorization if required. A nurse coordinator or licensed social worker may help manage the psychosocial needs of the patient and family and act as an advocate. Geneticists and genetic counselors can refine the genetic testing strategy, discuss results with families and help to arrange relevant autopsy examinations when indicated. Key members of any

team are practitioners who are skilled in performing the fetal interventions. Other medical specialists should be involved as required in each case. A perinatal or pediatric palliative care service is important for cases in which a fetal death or complicated neonatal course are anticipated.

A data coordinator is invaluable in ensuring that key indicators of care quality and outcome are monitored and can be audited and reported to internal and external registries, funding agencies and patients, as needed[2]. Given the ethical challenges entailed in certain, particularly innovative, fetal interventions, the involvement of the institutional ethics committee in such circumstances is vital.[2,28–30]

III. Diagnostic Services

A fetal therapy center needs to have access to appropriate diagnostic services for all conditions that they intend to manage. This includes imaging specialists skilled in the performance of detailed fetal ultrasonography, fetal echocardiography and cardiovascular imaging, and magnetic resonance imaging (MRI). Imaging expertise has to include prognostic staging for conditions such as congenital pulmonary airway malformations (CPAM)[34], congenital diaphragmatic hernia (CDH)[35], congenital heart disease (CHD)[36. 37], fetal hydrops[38], twin-twin transfusion syndrome (TTTS)[39, 40, 41], as well as ultrasonography for procedural guidance. MRIs should be interpreted by a board-certified imaging radiologist, with specific expertise in fetal MRI. For complex cardiac conditions, a pediatric cardiologist with expertise in fetal echocardiography and postnatal cardiac management must be involved.

All imaging personnel I should be accredited with their respective professional membership associations, e.g. Registry of Diagnostic Medical Sonographers (RDMS), American Institute of Ultrasound in Medicine (AIUM), American College of Radiology (ACR) or Canadian Association of Radiologists (CAR). They should maintain their required competencies and regularly participate in continuing medical education (CME), which will enhance the quality of the services that they provide[42]. A fetal therapy center needs access to the full range of genetic, microbiology, hematology, pathology, and laboratory services with the requisite expertise to allow the correct interpretation of fetal test results[43–47].

IV. Facilities needed to offer fetal therapy and maternal, fetal and neonatal care

Appropriate clinical facilities should be identified where fetal interventions can be performed, and where post-procedure monitoring and recovery of the pregnant patient and fetus(es) can occur. Depending on the nature of the procedure and gestational age, this may be in the imaging facility, fetal medicine unit, operating room, or labor & delivery (L&D) suite. After fetal viability, all fetal therapy procedures should be performed in areas with access to a L&D suite and neonatal intensive care unit (NICU). Operative and monitoring equipment needs to be available and should be regularly serviced. The capacity for rapid provision of red blood cell or platelets for intrauterine transfusion as well as medications for fetal administration is necessary at any fetal therapy center.

V. Policies, Organization, Conduct and Governance

Fetal therapy centers should offer evidence-based therapies that are subject to institutional oversight, and provide transparent and complete reporting of maternal and fetal outcomes. Innovative interventions, including any that entail substantial modification to accepted protocols or procedures, should be undertaken only with prior in-depth discussion, review and consensus-based approval by the relevant subspecialties and potential consultation with an institutional ethics committee or panel[48, 49]. Research must be conducted with IRB approval and oversight including registration as a clinical trial when appropriate. The fetal therapies that are offered, their eligibility criteria, as well as the mechanisms to introduce new therapies, should be clearly established at each institution and reviewed periodically, as part of a formal institutional or departmental quality assurance process.

For those who choose pregnancy termination, a process should be in place to ensure access including referral to another accommodating practitioner or facility if abortion services are not available at the fetal center[50].

VI. Fetal Therapy Oversight

A multidisciplinary fetal therapy advisory committee ideally includes representation from a variety of healthcare workers including MFM specialists, pediatric surgeons, anesthesiologists, neonatologists, geneticists, social workers, nurses, perinatal medical ethicists and other *ad hoc* members, as appropriate, who may or may not be involved in the direct care of the patient. The composition, role and responsibilities of such a committee may be modified, depending on the specific needs of a fetal therapy center and could range from quality assurance or audit through clinical oversight. Committee members might review proposed interventions which are considered (locally) innovative or experimental, evaluate research proposals before their submission, participate in trial related data safety monitoring boards, or conduct case reviews.

VII. Maintenance of competency and center performance

Achieving optimal maternal and fetal outcomes is dependent on a number of factors including practitioner and team experience, local resources and setting, case volume, ongoing audit and maintenance of competency of the whole healthcare team[51–53]. The association between surgical volume and improved outcomes has been attributed to multiple factors including team proficiency, and their ability to triage, recognize and manage specific complications within a particular health care system[54–60].

Developing relevant, agreed upon outcome measures for specific interventions, which are frequently evaluated and monitored, will help to prospectively evaluate fetal intervention risks, as well as the overall performance of fetal therapy treatments. Outcomes relevant for any fetal intervention include i) PPROM, preterm birth, mode of delivery, stillbirth or neonatal demise, ii) maternal complications such as hemorrhage, infection, pulmonary edema or ICU admission, iii) the frequency with which the intended treatment outcome was achieved, and iv) the impact on future fertility and pregnancy outcomes[2–7, 61]. Core outcome sets are being developed in fetal medicine and currently exist for twins, TTTS, CDH, fetal myelomeningocele closure and fetal growth restriction[6, 61–64]. Centers should also develop

or participate in needs-specific CME and quality improvement programs, which may include the use of simulation training models, to help develop and maintain their competence in specific fetal interventions[65–67].

FETAL THERAPY CENTER CARE LEVELS – PRINCIPAL CONSIDERATIONS

A fetal therapy center needs to have all of the resources to carry out fetal interventions and to manage any maternal, fetal or neonatal complications that might arise. We are proposing a three-tiered model to optimize the delivery of care at each level of case complexity, which may entail regionalized concentration of some subspecialized healthcare services[7–11]. The underlying fetal condition, type of intervention and expected treatment outcomes are the primary factors determining these proposed tiers and resource settings. Intervention-related risks can occur independent of experience or case volume, and particularly maternal complication rates tend to be underreported[68–75]. Patient safety requires a care setting that, at very least, can manage common (>1%), as well as infrequent but severe complications[7, 75,76]. The care level documents for maternal[8], neonatal[9] and pediatric surgery[10] provide the underlying framework that was adapted for fetal therapy centers.

Maternal Levels of Care

Aside from accredited birth centers, maternal care settings have been stratified into four levels in the USA. Of these, levels III (subspecialty care) and IV (regional perinatal center) have board certified obstetricians, MFM subspecialists, obstetric anesthesiologists and adult subspecialists, with ICU facilities on site that accept individuals who are pregnant or in the postpartum period; both levels III and IV allow access to the full range of expertise that may be necessary for any maternal or fetal intervention[8,9,10, 76, 77, 78]. The on-site ICU care at a level IV center allows for primary or co-management by a MFM team with expertise in complex medical conditions, critically ill or unstable mothers.

Neonatal Levels of Care

Within the four neonatal care levels, level III and IV NICUs have attendant neonatologists, nurse practitioners, respiratory technologists and pediatric anesthesiology services either on-site, or readily available at an adjacent institution. While level III NICUs can provide prolonged support for all degrees of prematurity, the ability to provide on-site subspecialty care, including the surgical management of complex congenital abnormalities, is limited to level IV NICUs or pediatric ICUs (PICU) [9,10]. Neonatal outcomes are improved the closer the delivery occurs to a pediatric center which can provide a full range of medical and surgical care[79–85]. All fetal interventions that may potentially result in (iatrogenic) preterm delivery after viability require, at least, level III NICU support. Complex neonatal management challenges, including those encountered with congenital anomalies, may benefit from access to a level IV NICU with subspecialty resources[86–90]. Surgical care of babies with congenital anomalies is optimized in the highest level pediatric surgery facility, which is required for level IV NICU or PICU designation[9,10].

Considerations for Selecting Necessary Level of Care

Prior to performing any fetal intervention, factors such as gestational age, fetal condition, procedure-related maternal, fetal, or preterm delivery risks, as well as the potential need to deliver outside the patients' community must be evaluated in order to determine whether the case can be managed locally or if transfer to a higher level facility should be considered. It is important that each fetal therapy center has strong institutional backing and that specific policies are in place to support a collaborative multispecialty model.

Risk profile and complexity of fetal interventions

The overall risk profile and complexity of any fetal intervention is related to its degree of invasiveness and the required interventional set-up. These factors also determine the type of anesthesia or analgesia required[1, 2], as well as the need for maternal and fetal monitoring during and after the procedure. Neonatal risks are determined by the potential risk of delivery soon after the intervention, gestational age at the time of intervention, and the neonatal management needs specific to the fetal condition. Therefore, neonatal care needs can range from management of prematurity to multidisciplinary management of coexisting conditions. We propose that fetal interventions be categorized at three levels (1) needle-based, (2) percutaneous, (3) open or laparotomy. These levels dictate the resource setting in which these procedures can be safely performed.

Ultrasound-guided needle-based fetal therapy interventions): For these procedures, a fine needle is advanced into a target under continuous ultrasound guidance. This approach is used for chorionic villous sampling, amniocentesis, amnioinfusion, amnioreduction, fetal fluid drainage, fetal blood sampling (FBS), intrauterine transfusion of blood products (IUT)[91,92], direct delivery of fetal medications[93], fetal or placental interstitial vascular occlusion[94–97] and fetal cardiac interventions[25] (Table 1). Needle-based procedures typically require only local anesthesia, but may occasionally require intravenous (IV) conscious sedation and, very rarely, neuraxial anesthesia[98]. The principal maternal risks include post-procedural pain, PPROM, preterm labor and the need for emergent delivery for fetal distress (Table 1). After viability, intra-operative fetal surveillance may be used to identify any signs of compromise that might require either intrauterine resuscitation or delivery. After the procedure, maternal monitoring for obstetric complications and fetal heart rate monitoring after viability are performed.

Percutaneous fetal interventions—Percutaneous interventions include ultrasound-guided bipolar cord coagulation[99, 100], radio frequency ablation (RFA)[101], shunt procedures[102–110] and fetoscopy for laser umbilical cord occlusion[111], laser ablation of placental vascular anastomoses[112, 113], fetoscopic endotracheal occlusion (FETO)[114], amniotic band resection[115] and percutaneous fetal myelomeningocele closure[116–119] (Table 2). Fetoscopic interventions or bipolar forceps procedures are performed using a combination of ultrasound guidance and direct visualization entering the uterus directly or through a sheath. Percutaneous fetoscopic fetal myelomeningocele closure notably may employ multiple ports. With increasing invasiveness, procedure duration and complexity, the anesthetic requirements increase correspondingly, from local anesthesia to conscious IV sedation (monitored by the anesthesiology team) to neuraxial or general anesthesia.

Following these type of procedures, surgical complications, such as trocar site bleeding, intraperitoneal amniotic fluid or CO_2 leakage, and occasionally even pulmonary edema or need for ICU admission may be encountered. These risks, as well as the potential obstetric complications of PPROM and preterm labor, require maternal or fetal post-procedure monitoring on a L&D unit, and occasionally access to adult ICU services. Patients undergoing FETO may require the emergent removal of a tracheal balloon, necessitating 24/7 availability of an *Ex-utero* Intrapartum Treatment (EXIT) team, in the event that a balloon is still *in-situ* if preterm labor occurs and cannot be removed either by ultrasound-guided needle puncture or fetoscopically[114, 120, 121]. Following delivery, neonates with spina bifida or CDH are likely to need management in a level III-IV NICU or PICU.

Fetal interventions requiring laparotomy—Fetal interventions requiring a maternal laparotomy and hysterotomy (i.e., “open fetal surgery”) include open fetal myelomeningocele closure[122], resection of fetal tumors such as a sacrococcygeal teratoma (SCT)[123–126] and the EXIT procedure for airway obstruction[127, 128]. Although open fetoscopic fetal myelomeningocele closure avoids a hysterotomy, the maternal laparotomy itself carries comparable operative risks[129, 130] (Table 3). Open procedures are performed under general anesthesia, aided by neuraxial anesthesia, for intrapartum and postpartum pain management, and require more sophisticated intra-operative maternal and fetal monitoring. The procedural set-up, as well as the requisite operator and multidisciplinary team expertise, is most demanding for these procedures and access to the highest-level of maternal (level III or IV) and neonatal care resources is required. Following a procedure, the mother and fetus need to be monitored in a L&D setting, with ready access to ICU resources if needed.

PROPOSED LEVELS OF CARE FOR FETAL THERAPY CENTERS

The care level of a fetal center is defined by the presence of resources tailored to the level of complexity of the intervention and ability to manage anticipated maternal, fetal and neonatal complications. Based on the complexity and risk profile of fetal interventions, three levels of fetal care are proposed.

LEVEL I

A level I fetal therapy center should be capable of offering fetal interventions that may be associated with the obstetric risks of PPROM and preterm birth, but which would be very unlikely to require maternal medical subspecialty or ICU care (Box 2). Neonatal risks should not exceed those of moderate prematurity (i.e. 32–37 weeks’ gestation)[131] and a neonate should be unlikely to require any subspecialty medical or surgical care. Maternal care resources should meet ACOG/SMFM level III obstetrical care center standards and the NICU should be level III. Following a procedure, maternal and fetal monitoring should be supervised by the MFM team members of the fetal therapy center. In experienced hands needle based procedures and trans-placental medical therapy can be performed at a level I fetal therapy center (Box 2). After viability, interventions carrying a risk for fetal distress should be performed with ready access to a L&D unit and NICU. If any procedure is felt to be beyond the expertise of the local practitioners, or if the local supportive care resources are insufficient, referral to an institution where these can be met should be initiated, if feasible.

LEVEL II

A level II fetal therapy center should be capable of offering fetal interventions which also carry risks that might necessitate maternal ICU admission or could result in very preterm birth after viability (Table 4). While most level II fetal centers will be capable of managing the majority of maternal risks associated with any particular fetal intervention, the pediatric specialty resources to manage some of the more challenging neonatal issues *may* not be immediately available. Maternal care resources should comply with ACOG/SMFM level III or IV obstetrical care center standards, while a level III NICU is sufficient (Box 2). Level II fetal care centers should be capable of offering the full range of procedures performed at a level I center, but could also manage more complex ultrasound guided procedures and fetoscopies as well mothers with comorbid conditions or high BMI (Box 2). After viability, fetal therapy should only be offered for conditions for which the appropriate level of neonatal care is available. A level II center might, on a case by case basis, be capable of performing a prescheduled EXIT procedure, presuming on-site availability of the relevant pediatric airway expertise.

LEVEL III FETAL THERAPY CENTER

A level III fetal therapy center can offer the full range of minimally invasive and open fetal interventions and can manage all levels of maternal or neonatal risk or complications that might be encountered with such procedures (Box 2). These centers will have level III or IV maternal care services with ready access to a level IV NICU or PICU with the full range of pediatric subspecialties. A level IV maternal care center allows co-management or close collaboration between ICU and MFM subspecialists. A level III fetal center can offer the complete range of fetal therapy, including all therapies offered at level I and II centers, FETO for CDH and all open fetal surgical procedures. It can also manage fetal conditions, such as compromised CPAM, fetal hydrops, CDH and spina bifida. The center should also have the capability to rapidly assemble complex medical teams on a 24/7 basis (e.g., for EXIT)[133].

SUMMARY

Development of a fetal therapy center is a multi-disciplinary endeavor guided by the principles of fetal therapy including the need to provide maternal safety and autonomy while also optimizing fetal neonatal and maternal outcomes. The fetal interventions offered should reflect the available expertise, resources and degree of institutional support. This document proposes three levels of care for fetal therapy centers. Our intention is to provide guidance for the optimal care setting in which fetal interventions can be offered. Multidisciplinary care is fundamental to the establishment and operation of a fetal therapy center. The proposed fetal levels of care are aligned with existing levels of care for maternal, neonatal and surgical care., In the absence of any central, national or international regulatory body at present, it is the responsibility of the leadership at each fetal therapy center to ensure appropriate staff credentialing, resource planning, quality benchmarking, and outcome reporting for any intervention offered at that institution. This document is intended as a guide for the optimal resources that ought to be in place to facilitate fetal therapy. It is

not intended to impede the development of new fetal centers, but rather to assist them in considering the necessary components to ensure patient safety and procedural success. As the technology, instrumentation and procedures in fetal therapy evolve, different resources may be suggested. The overarching goal is continued advancement of fetal therapy through provision of safe and effective treatment of fetal disease.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Box 1.

Itemized Core Components for the General Practice of Fetal Therapy

Oversight

Medical director of fetal therapy center: direction and oversight of all fetal therapy operations

Nursing director of fetal therapy center: direction and oversight of all fetal therapy care

Multidisciplinary group of caregivers: direction and oversight of disease specific care-paths and therapies through multi-disciplinary input – Implementation of interventions through a predefined team approach

Regular, (at least monthly) multi-disciplinary patient care case conferences: planning and reviewing patient care and outcomes

Accredited diagnostic services

Prenatal ultrasound, magnetic resonance imaging, and fetal echocardiography: accurate diagnosis of fetal condition and monitoring of therapy

Genetics: diagnosis and counseling regarding genetic diseases

Access to reference laboratory and pathology services: chemistry, hematology, immunology, histology, metabolic and infection diagnostic tests

Electronic medical record and picture archiving and communicating systems for patient related diagnostic and care-related information

Maternal care services

Obstetric services/maternal–fetal medicine: management of maternal and obstetric care needs and complications

Obstetric anesthesia: maternal management during obstetric or fetal interventions

Adult medicine: consultation, co-management of maternal medical conditions, or complications of pregnancy or treatment

Intensive care unit: management of maternal critical illness related to pregnancy or treatment

Neonatal and pediatric care services

Neonatology: prenatal consultation; bridge to post-natal follow-up, neonatal care

Pediatrics: prenatal consultation, neonatal and pediatric management

Pediatric surgery: prenatal consultation and postdelivery management

Pediatric anesthesia: fetal management during interventions

Respiratory technologist or anesthetic assistant: fetal management during interventions

Pediatric cardiology: Prenatal diagnosis and consultation, postnatal management, fetal hemodynamic monitoring during complex procedures or transplacental medical therapy, neonatal cardiac care

Additional care services

Social work and spiritual support: coordination of social services, patient advocacy

Patient services coordinator, financial counselor: scheduling of appointments, financial planning assistance and insurance authorization across all involved care specialties

Data coordinator: tracking and facilitating the reporting of outcomes related data of the fetal therapy center

Interpreting and cultural diversity specialist: consultation, consent, follow up services with availability especially when multiple therapeutic options are being entertained

Family planning: safe pregnancy termination and contraception counseling

Palliative care: palliative neonatal care, perinatal hospice services

Research regulatory and ethics

Institutional research review boards (IRB): oversight of experimental and research-related interventions

Medical ethicist: consultation and oversight as needed, for research and ethical questions that arise during clinical care

Database and IT support: data collection for sharing, reporting QI, and research

Data from Moon-Grady AJ, Baschat A, Cass D, Choolani M, Copel JA, Crombleholme TM, et al. Fetal Treatment 2017: The Evolution of Fetal Therapy Centers - A Joint Opinion from the International Fetal Medicine and Surgical Society (IFMSS) and the North American Fetal Therapy Network (NAFTNet). Fetal Diagn Ther 2017;42:241–8. doi: 10.1159/000475929

IRB= institutional review board, IT= Information technology, PACS=picture archiving & communication system, EMR= electronic medical record, QI=quality improvement

Box 2.

Proposed Fetal Therapy Levels and Specific Resource Setting

Level I
Definition: Fetal therapies with low maternal and/or fetal risk
Personnel: Fetal therapy center team, supported by institutional infrastructure
Maternal care level: At least level III
NICU care level: At least level III
Examples of procedures: Fetal blood sampling, uncomplicated IUT [++], fetal shunt placement, radiofrequency or interstitial laser ablation, fetal antiarrhythmic treatment [***].
Additional consideration: Mechanism in place to evaluate case complexity prior to interventions and transfer care to a higher level fetal therapy center if required.
Level II
Definition: Fetal therapies with low or high maternal risk, but low neonatal risks
Personnel: Fetal therapy center team supported by institutional infrastructure
Maternal care level: At least level III
NICU care level: At least level III
Pediatric surgery care level: Level 1 for all conditions where a fetal intervention is offered
Examples of procedures: All procedures performed at level I centers, with the addition of complicated IUTs [++], fetoscopic laser ablation for TTTS, ultrasound guided cord or vascular occlusions, fetoscopic amniotic band resection, fetal cardiac interventions [*], uncomplicated EXIT procedure [**]
Level III
Definition: All fetal therapies, irrespective of their risk level
Personnel: Fetal therapy center team, supported by institutional infrastructure
Maternal care level: At least level III
NICU care level: Level IV
Pediatric surgery: Level 1 for all conditions
Examples of procedures: All procedures performed by level I and II centers irrespective of the level of fetal compromise or procedural challenge, plus FETO balloon placement and retrieval, complex multi-disciplinary fetoscopic procedures, open fetal surgery, 24/7 availability of EXIT

Legend: TTTS= twin-twin transfusion syndrome, FETO= fetoscopic tracheal occlusion, EXIT= *ex-utero* intrapartum treatment, IUT = intrauterine transfusion

[++] complicated IUTs refer to procedures < 20 weeks gestation, in the presence of a compromised or hydropic fetus or with a large maternal BMI

[**] uncomplicated EXIT refers to procedures that can be scheduled electively, well in advance and where all required resources are available

[*] only to be undertaken if the disease specific pediatric care services are present ideally at that institution or else by remote virtual consultation

[***] maternal Digoxin, Sotalol, Flecainide or Amiodarone treatment should be undertaken with input from and neonatal follow-up with fetal/pediatric cardiology.

Table 1.

Ultrasound guided needle based fetal interventions

PROCEDURE	REPORTED PROCEDURAL RISKS	REQUIRED RESOURCES
Fetal blood sampling and transfusion[19, 21, 70, 91, 92] Needle size: 22–20 gauge (outer diameter 0.71–0.91 mm)	**Maternal:** Urgent delivery	**Maternal:** L&D unit if viable; OB anesthesiology for IV conscious sedation[84] or rarely neuraxial anesthesia[85]
	Fetal: Puncture site bleeding 20–30%; transient bradycardia 5–10%; fetal death 0.4%; up to 25% for complicated fetal disease and hydrops.	**Fetal:** Trained intervention team, Blood bank for preparation of fetal blood products, medications for fetal paralysis/ resuscitation.
	Neonatal: Premature delivery (average gestational at birth: 31–35 weeks; condition specific)	**Neonatal:** NICU if viable with subspecialty access for complex or severe conditions
Fetal cardiac interventions[25, 81] Needle size 18–16 Gauge (outer diameter 1.27 – 1.65 mm)	**Maternal:** Post-operative pain up to 32%; post-operative nausea or vomiting up to 26%	**Maternal:** L&D unit if viable; OB anesthesiology for sedation / neuraxial / general anesthesia as required
	Fetal: Transient hemopericardium 18%–28%; ; Bradycardia up to 32; IUFD by 48 hours 10–30%	Multidisciplinary fetal cardiac intervention team (Blood bank to prepare fetal blood products) ** Medication for fetal paralysis/ resuscitation
	Neonatal: Premature delivery (<37 weeks up to 20%; fetal death before discharge up to 61%)	**Neonatal:** NICU, with pediatric cardiology / cardiac surgery, pediatric anesthesiology and subspecialty access
Radiofrequency, microwave, or interstitial laser ablation[95–97, 100, 101] Instrumentsize: 18–16 Gauge (outer diameter 1.27–1.65 mm)	**Maternal:** Myometrial bleeding <1%	**Maternal:** Dedicated intervention setting, OB Anesthesiology for IV conscious sedation and, rarely, neuraxial anesthesia; L&D unit for post-procedure monitoring
	Fetal: Miscarriage within 2 weeks 3%; thermal injury of co-twin 2%; co-twin demise 10–16%; PPROM within 2 weeks 2–9%	**Fetal:** Trained intervention team
	Neonatal: Premature delivery (<32 weeks 9–18%; <37 weeks 9–18%)	**Neonatal:** NICU after viability

Legend: Ø = diameter, OB anesthesiology = Obstetric Anesthesiology, LUTO = lower urinary tract obstruction, L&D = Labor & Delivery, NICU = neonatal intensive care unit, PTB = preterm birth, PPROM = preterm premature rupture of membranes.

** Not typically used, but may be required on a case by case basis in the absence of fetal compromise.

Table 2.

Ultrasound guided shunting or fetoscopic fetal interventions

PROCEDURE	REPORTED PROCEDURAL RISKS	REQUIRED RESOURCES
Shunting procedures[103–110] Instrument diameter: 6–9 French (1.83–3 mm)	**Maternal:** Myometrial bleeding <1%	**Maternal:** L&D unit if viable; OB anesthesiology for iv conscious sedation or rarely neuraxial anesthesia
	Fetal: Shunt failure/dislodgement 8–35%; Chorio-amnion separation up to 7.7%; PPROM up to 10%; fetal death up to 12%	**Fetal:** Trained intervention team, medications for fetal administration as required.
	Neonatal: Premature delivery (<34 weeks up to 56%); NICU admission up to 83%; neonatal death up to 22%	**Neonatal:** NICU if viable with sub-specialty access as dictated by the fetal disease *per se*.
Bipolar or fetoscopic cord coagulation[76, 95, 96, 97] Instrument diameter: 1.5–5 mm	**Maternal:** Trocar site bleeding 1–3%	**Maternal:** Dedicated intervention setting, L&D unit; OB anesthesiology for IV conscious sedation or neuraxial anesthesia as required
	Fetal: Co-twin demise 8–14%; PPROM < 32 wks 23–34%; Chorio-amnion separation 5–10%	**Fetal:** Trained intervention team with specific procedural expertise at the expected level of complexity
	Neonatal: Premature delivery (< 32 weeks 23–34%); neonatal death 6–12%	**Neonatal:** NICU if viable with subspecialty access if more severe fetal disease is present
Fetoscopic laser surgery[18,22, 76, 74, 134, 132] Instrument diameter: 5–12 French (1.5–4 mm)	**Maternal:** pulmonary edema 1–8%; ICU admission 1–2%; trocar site bleeding 5–7%; maternal blood transfusion up to 2.9%; intra-abdominal fluid leakage 1–7%	**Maternal:** Dedicated intervention setting, L&D unit, OB anesthesiology for IV conscious sedation or neuraxial anesthesia as required, Blood bank, ICU availability
	Fetal: PPROM <24 hrs. 3–4%; Chorioamnion separation 5–10%; placental abruption 1–3%; PPROM < 32 wks 19–34%;	**Fetal:** Trained intervention team with specific procedural expertise at the expected level of complexity
	Neonatal: Preterm birth < 33 weeks up to 36%	**Neonatal:** NICU if viable, access to pediatric cardiology access with severe fetal disease
Fetoscopic endotracheal occlusion (FETO)[76, 114, 120, 121, 132] Instrument diameter: 10 French (3.3 mm)	**Maternal:** abdominal hemorrhage 0.5%	**Maternal:** Dedicated intervention setting, L&D unit, OB anesthesiology for iv. conscious sedation or neuraxial anesthesia as required, Blood bank, ICU availability
	Fetal: fetal death: 2%; unscheduled balloon removal up to 56%, unscheduled EXIT up to 7%	**Fetal:** Expertise with FETO procedure, On-call multidisciplinary team for emergent balloon removal or EXIT.
	Neonatal: PTB < 34 weeks up to 31%; postnatal balloon removal up to 17%	**Neonatal:** NICU, PICU, Pediatric Surgery, Pediatric anesthesiology, Pediatric cardiology, ECMO, Pediatric ENT
Percutaneous fetoscopic MMC closure[116–119, 130] Instrument diameter 10–15 French (3.3–5 mm), up to 4 ports.	**Maternal:** Pulmonary edema 2%; abdominal CO_2 leak 20–33%	**Maternal:** Dedicated intervention setting, L&D unit, OB anesthesiology for iv. conscious sedation, neuraxial or general anesthesia as required, Blood bank, Adult ICU
	Fetal: PPROM < 34 wks: 67%	**Fetal:** Fetal MFM surgeon, pediatric neurosurgery
	Neonatal: PTB < 35 weeks up to 23%; CSF leakage at birth up to 32%	**Neonatal:** NICU with subspecialty care, pediatric neurosurgery, pediatric anesthesiology

Legend:, MFM= Maternal-Fetal Medicine, OB Anesthesiology = Obstetric Anesthesiology, NICU = neonatal intensive care unit, PTB = preterm birth, L&D = Labor & Delivery, LUTO = lower urinary tract obstruction, PICU = pediatric intensive care unit, PPROM = preterm premature rupture of membranes, EXIT = ex-utero intrapartum treatment, ECMO = extracorporeal membrane oxygenation.

Table 3.

Fetal interventions requiring maternal laparotomy

PROCEDURE	REPORTED PROCEDURAL RISKS	REQUIRED RESOURCES
Open fetoscopic MMC closure [119, 129, 130] *(i.e. via laparotomy & fetoscopy)*	**Maternal:** Pulmonary edema up to 9%	**Maternal:** Dedicated intervention setting, L&D unit, OB anesthesiology for neuraxial or general anesthesia and post-operative pain management as required, Blood bank, Adult ICU
	Fetal: PPROM < 37 wks up to 25–38%	**Fetal:** Fetal MFM surgeon, Pediatric neurosurgery, pediatric surgery, pediatric anesthesiology
	Neonatal: Premature delivery (< 35 weeks 45–52%); perinatal death 3–6%; dehiscence at repair site 4.3–13%	**Neonatal:** NICU with subspecialty care, Pediatric Neurosurgery
Open fetal MMC closure [71, 72, 73, 76] *(i.e. via laparotomy & hysterotomy)* **Open fetal surgery** [76, 119, 123, 126,]	**Maternal:** Pulmonary edema 2–6% (up to 27.8% for open fetal surgeries)[144] Intra-operative blood transfusion 1–6% (fetal myelomeningocele repair), 9–13% for other open fetal surgery; ICU admission up to 24.6%,; intubation for > 48 hours up to 2.3%	**Maternal:** Dedicated intervention setting, L&D unit, OB anesthesiology for neuraxial or general anesthesia and postoperative pain management as required, Blood bank, Adult ICU
	Fetal: Bradycardia requiring resuscitation 5–10%; PPROM < 37 wks: 32–46%; fetal death up to 4.3%[144]	**Fetal:** Fetal MFM surgeon, pediatric neurosurgery, pediatric surgery, pediatric anesthesiology, fetal echocardiography, pediatric subspecialties
	Neonatal: Premature delivery (< 35 weeks 45–52%); perinatal death 3–6%; dehiscence at repair site in current or future pregnancies 4.3–13%	**Neonatal:** NICU with subspecialty care, e.g., Pediatric Neurosurgery or other condition specific specialties.
Ex-utero intrapartum treatment (EXIT) [76, 127, 128]	**Maternal**: intra-operative atony and hemorrhage	**Maternal:** Dedicated intervention setting, L&D unit, OB anesthesiology for neuraxial or general anesthesia as required, Blood bank, Adult ICU
	Fetal: Perinatal death 3–14% usually attributable to primary pathology.	**Fetal:** Multidisciplinary intervention team
	Neonatal: Premature delivery (average GA 31–36 wks).	**Neonatal:** NICU with subspecialty care

Legend: PTB = preterm birth, ICU = intensive care unit, GA = gestational age, L&D = Labor & Delivery.