SFM Fetal Therapy Practice Guidelines: Fetoscopic Endoluminal Tracheal Occlusion

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Introduction

Fetoscopic endoluminal tracheal occlusion (FETO) was started as an experimental therapy in fetuses with congenital diaphragmatic hernia (CDH) who had a bad prognosis. The Tracheal Occlusion To Accelerate Lung growth-trial (TOTAL) has proved its effectiveness. The intervention attempts to correct pulmonary hypoplasia before delivery to reduce perinatal and neonatal mortality and morbidity.

Pulmonary Hypoplasia

- Severe pulmonary hypoplasia is defined as a 25% increase in the lung area to the head circumference (with or without liver herniation).
- Moderate pulmonary hypoplasia is defined as 25 to 34.9% observed to expected lung area to head circumference ratio (LHR; liver location not considered), or observed to expected LHR of 35 to 44.9 with liver in the chest assessed at 32 weeks and 5 days or later.
- Right sided CDH was not included in the TOTAL trial (FETO can, however, be offered).

Criteria for Eligibility

- Fetuses with severe diaphragmatic hernia (LHR <1 and liver herniated into the chest) identified between 22 $^{0/7}$ weeks and 29 $^{6/7}$ weeks of gestation.
- The mother must be at least 18 years old.
- Singleton pregnancy.
- Left sided diaphragmatic hernia.
- A fetal echocardiography confirms that there are no severe cardiac anomalies.
- Normal chromosomes and no related aberrations (microarray exome sequencing recommended).
- A cervix that is longer than 15 mm in length.
- The absence of maternal contraindications to abdominal-fetoscopic surgery or general anesthesia.
- No maternal latex allergy.
- Acceptance of responsibility for attending the FETO center for balloon removal.

Prerequisites

- A detailed anomalies scan and fetal magnetic resonance imaging (MRI).
- Personalized outcome prediction based on measures of the lung size, liver position, and side of defect.
- LHR: The lung contralateral to the lesion is measured in a standard four chamber view plane of the heart and the head circumference is measured in the standard transthalamic plane.
- The most precise method is to trace the contour of the lung.
- Observed to expected LHR.
- MRI: (1) Volumetric measurement of both lungs, (2) quantification of liver herniation, and (3) detailed examination of the stomach position.

Maternal Risks

- Preterm spontaneous rupture of membranes (18.1–27.3%).
- Chorioamnionitis.
- Antepartum hemorrhage (rare).

Fetal Risks

- Balloon collapse.

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Other Risks

- Anesthesia risks.
- Tracheal widening without major complications (neonatal period).
- Prolonged coughing (neonatal period).

Patient Information Leaflet

1. What exactly is FETO?
   It is a minimally invasive surgical treatment used to treat the most severe forms of CDH discovered before the baby is born. Treatment during pregnancy can help the lungs to grow more fully and raise the baby's chances of survival in the most severe situations.
2. How is FETO carried out? (►**Figs. 1**–**5**)
   A balloon is used to restrict the baby's airways in order to encourage lung growth. During a FETO procedure, a balloon is put into the baby's trachea using a minimally invasive method between 27 and 31 weeks of gestation. A balloon is then introduced into the trachea with a surgical device and inflated with fluid to block (occlude) the trachea. The balloon does not obstruct fetal respiration prior to birth. The balloon is placed for 4 to 6 weeks, until 34 weeks of gestation, when it is deflated or removed in a second procedure. This treatment may also be required in an emergency. Neonatal care will be provided at birth, and surgery to seal the diaphragm hole will be undertaken. It is only offered in cases of severe CDH where we believe the mother and infant will benefit the most from the operation.
3. FETO evaluation.
   - Detailed ultrasound anomalies scan.
   - MRI (optional).
   - Fetal echocardiography.
   - Exome sequencing from amniotic fluid.

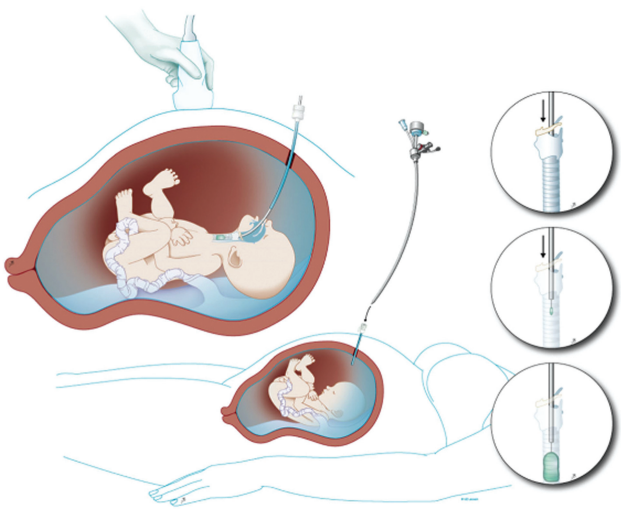

Fig. 1 Fetoscope introduced under ultrasonography (USG) guidance.

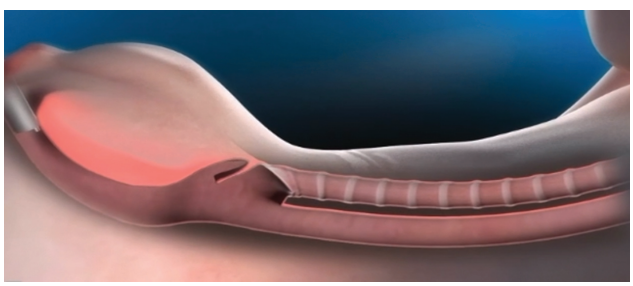

Fig. 2 Fetoscope being introduced in fetal mouth.

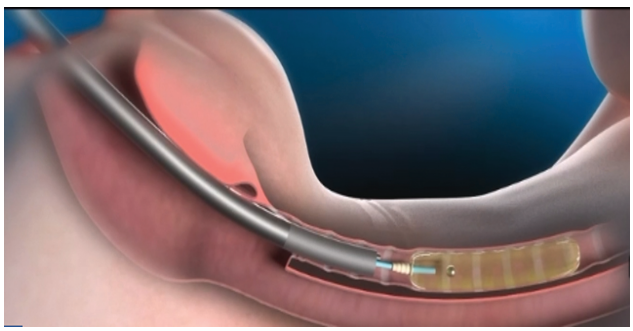

Fig. 3 Balloon being inflated.

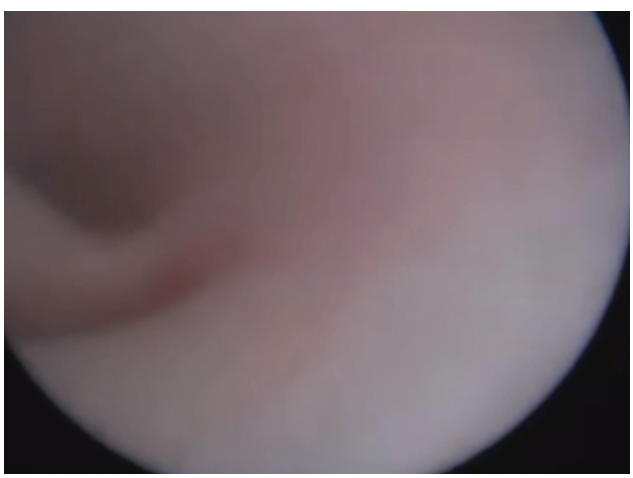

Fig. 4 Vocal cords being visualized.

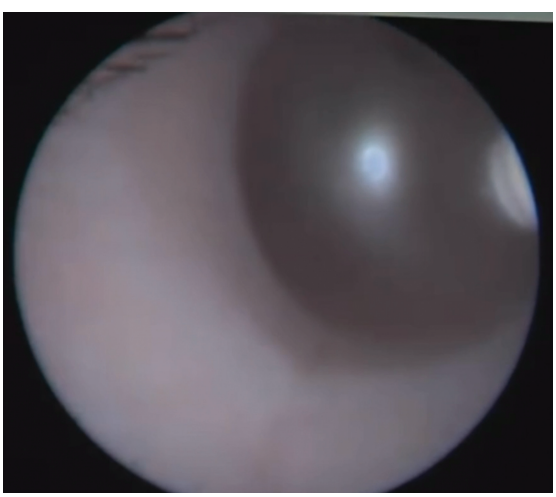

Fig. 5 Balloon being inflated.

4. Need for follow up?
   The pregnancy has to be followed up at the center every 2 weeks until delivery.
5. Where will the baby be delivered?
   At a tertiary neonatal care center with an experienced pediatric. This is because your baby's airway is temporarily closed, and an unexpected delivery could be fatal without skilled intensive care. In the event of an emergency, you must stay within 30 minutes of the hospital.

Counseling Statement for Medical Records

- This method has proved effective for severe CDH.
- Personalized prognosis.
- FETO improves survival from 24 to 49% in patients with left CDH and an observed/expected LHR of less than 25%, and from 17 to 42% in patients with right CDH and an observed/expected LHR of less than 45%.[1–4]
- Fetal whole exome study prior to the operation.
- Admission requirements of 1 to 2 days.
- Planned follow up every week or every 2 weeks, with a necessity to stay within 30 minutes of the hospital in case the balloon needs to be removed urgently. Prenatal balloon removal is planned.
- The delivery must take place in a hospital with a tertiary neonatal intensive care unit (NICU) since the neonate must be monitored postnatally.
- Surviving patients may experience not only short and long term respiratory morbidity but also gastroesophageal reflux, failure to thrive, and less common orthopedic or other difficulties despite surgery.

Equipment and Devices

The fetoscopic instruments used for FETO and unplug are the following: 1.3-mm endoscope miniature telescopes with a 0-degree straightforward remote eyepiece, and 30.6-cm working length; 3.3-mm sheath blunt curved sheath with sand blasted echogenic tip with irrigation stop cock and two side apertures; 1-mm forceps 35-cm-long retrieval forceps with double action jaws; 0.4-mm stylet single use puncture stylet with adjustable torque, 50-cm-long; 3.3-mm trocar—10-Fr pyramidal tipped trocar for use with flexible cannula RCF-10.0 (Cook, Check Flo Performer); 0.6-mL balloon Goldbal 2 detachable latex balloon with radio opaque inclusion, outer diameter of 1.5 mm (inflated: 7.0 mm), length of 5.0 mm (inflated 20.0 mm); 0.9-mm microcatheter catheter loaded with mandrel, and Touhy Boost Y connection, max outer diameter 0.9 mm, tapered to 0.4 mm, 100 cm in length; direct bronchoscopy 1.3-mm endoscope miniature telescope, with remote eyepiece 0-degree straight forward, 18.8-cm working length; straight bronchoscopic sheath 4.2-mm outer and 3.5-mm inner diameter, 18.5 cm in length (size 2.5), is conventional neonatal "Doesel Huzly" bronchoscope, with blanking and suction plug; telescope bridge houses telescope and has side opening for irrigation 1.5-mm outer diameter; 1.0-mm forceps, 19 cm semiflexible forceps for balloon retrieval; and 0.4-mm stylet single use puncture stylet with adjustable torque, 50 cm long. These is a list of endoscopic instruments that have been developed by Karl Storz Endoskope. The balloon system is an adapted version of a commercially available vascular occlusion device. It is used off label. Currently Baltacci is not available in our country and is under procurement; Goldbal 2 off label is available for vascular occlusion. The Goldbal balloon has issues with import and is still a challenge to procure it in India.

Pre-op Checklist and Patient Preparation

- Consent.
- Antibiotic prophylaxis: cefazolin 2 g intravenously every 8 hours until 24 hours after the procedure or 900-mg clindamycin intravenously,
- Lignocaine test dose.
- Confirm Rh status.
- Intravenous (IV) access for the mother.
- Vaginal micronized progesterone 200 mg on the day and then for 2 days.
- Prophylactic tocolysis (nifedipine, alternatively atosiban if available).
- Indomethacin 50 mg oral followed by 25 mg every 6 hours (until 48 hours postprocedure).

Personnel Required

- Operator.
- Assistants: one trained in handling the ultrasound probe.
- Trolley assistant: for fetoscopy trolley.
- Circulating nurse to set tray and provide things.
- A sonographic assistant to handle the ultrasound.
- Anesthetist in case of spinal or epidural anesthesia.

Operating Room Requirements

The procedure may be performed in a clean ultrasound procedure room or in an operation theater. A good resolution color Doppler ultrasound machine is required.

Trolley Setting

General trolley:

- Sterile Prep Kit (sterile drapes, probe cover, sterile gel, SS cup, sponge forceps, gauzes).
- One percent lignocaine for maternal anesthesia.
- A no. 11 blade scalpel.
- Atracurium or vecuronium + fentanyl + atropine for fetal anesthesia.
- Suction apparatus (if amnioreduction is planned).
- A 5-mL syringe (for lignocaine), a 1-mL syringe (for fetal anesthesia), and a 22- or 23-gauge spinal needle (for fetal anesthesia).

Fetoscopy Trolley

- Fetoscopy equipment as mentioned in the section on equipment and devices.

Procedure Steps

1. Choice of anesthesia:
   a. Local/spinal/general as chosen by the mother.
   b. Fetal anesthesia (percutaneous ultrasound directed intramuscular combination of fentanyl (15 µg/kg), atropine (20 µg/kg), and vecuronium (0.1 mg/kg).
2. Preprocedure: May need external cephalic version; the mother may have to be repositioned as needed to the lateral decubitus position to access the fetal airway under ultrasound guidance.
3. Maternal abdomen is prepped and draped as usual.
4. An ultrasound probe is sanitized with antiseptic and draped in a sterile manner.
5. The access route is planned.
6. Fetal anesthesia as outlined earlier.
7. Maternal lignocaine infiltration from skin up to the peritoneum.
8. A 5-mm incision in the maternal skin.
9. A percutaneous technique, using an 18-gauge needle and the Seldinger technique, into the uterus under ultrasound guidance. A flexible 10-Fr cannula (3.3 mm) loaded with a pyramidal trocar is inserted into the amniotic cavity.
10. The cannula is used to insert a 1.3-mm fetoscope into the amniotic fluid. The endoscope is guided into the fetal larynx and through the vocal cords by utilization of both ultrasound guidance and direct endoscopic visualization.
11. Under ultrasound guidance and direct endoscopic visualization, correct positioning is confirmed by verifying tracheal rings. The endoscope is then guided into the fetal larynx and through the vocal cords. Once adequately positioned, the balloon is inflated with sterile saline to a diameter of 2.2 mm for a length of 2 cm to occlude the fetal trachea.
12. A single stitch is left in the skin after the endoscope and cannula are removed.

Post-op Checklist

- Document no free fluid in maternal flanks by ultrasound immediately after the procedure and 3 hours postprocedure.
- Document fetal heart activity and also show it to the mother after the procedure and after 3 hours.
- Bedrest for 24 hours after fetoscopic tracheal occlusion in the hospital.
- Patient advice on discharge:
  - Avoid overstraining/lifting heavy weights for a week.
  - Report to the hospital immediately if there is substantial leaking, bleeding, pain, generalized feeling of unwellness, or fever.
  - Continue indomethacin 25 mg 6 hours for a total of 48 hours (some centers continue nifedipine till 34 weeks).
  - Vaginal progesterone 200 mg once daily for 2 days (optional).
  - Adequate bedrest for 2 weeks.
- It is obligatory for the patient to stay within reasonable distance from the hospital to facilitate balloon removal in an emergency in case of preterm labor or prelabor rupture of membranes.
- Review once a week: Fetal lung volumes are measured weekly and amniotic fluid volume and membrane status are monitored.
- Serial growth scans are performed every 3 weeks and a follow up fetal MRI is performed 4 to 6 weeks post balloon occlusion.
- Amnio drainage is performed if the deepest vertical pool exceeds 12 cm.

Post-op Monitoring of Mother and Fetus

- Mother's pulse and blood pressure (BP) should be recorded before the procedure, during the procedure, and immediately after the procedure.
- Pulse and BP should be recorded every 30 minutes, every 1 hour, and then every 4 hours for 24 hours (unit protocol).
- Fetal heart activity is documented during and at the end of the procedure and before discharge.
- Maternal flanks should be imaged and assessed for free fluid 3 hours after the procedure. Free fluid with normal vitals is usually indicative of leaked amniotic fluid. This will usually get absorbed over 24 hours but may necessitate painkillers. If in doubt regarding the nature of the fluid, close monitoring with or without a diagnostic tap may be required.

Balloon Retrieval

Balloon retrieval is planned at 34 weeks; premature delivery is imminent.

- Retrieval is done fetoscopically. Tracheal fluid movement demonstrated with Doppler can confirm patency.
- Under ultrasound guidance (using a 22-gauge needle), the balloon can be punctured.
- In case preterm labor sets in with the balloon in situ, then an ex utero intrapartum treatment is conducted and the balloon is removed from the fetal airway by direct bronchoscopy or by tracheoscopic removal. This balloon placement facilitates lung maturation, improves survival chances, and definitely reduces morbidity.
- Maternal recovery after the balloon removal procedure is similar to that for balloon placement.

Conclusion

Latest systematic reviews[5] indicate FETO is linked to a decrease in mortality, decrease in the prevalence of pulmonary hypertension, and the need for extracorporeal membrane oxygenation (ECMO), but only in moderate CDH. FETO does not cause extreme preterm delivery; however, it does increase the chance of late prematurity.

Invasive Report Template

Patient Name
Age
Hospital ID
Gestational Age
Indication
Procedure Name
Maternal Anesthesia
Fetal Anesthesia
Control: Continuous ultrasound guidance
Insertion Needle: 22 gauge for fetal anesthesia
Uterine entry is with a disposable flexible 10-Fr cannula (3.3 mm) loaded with a pyramidal trocar, which is inserted into the amniotic cavity under ultrasound guidance. The area chosen for entry should be devoid of placenta and as perpendicular as possible to the nose tip.
Amnioinfusion: Yes/No
Amnio drainage: Yes/No
Intra operative complications:
Post-op advice:

Conflict of Interest
None declared.

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References

1 Van der Veeken L, Russo FM, De Catte L, et al. Fetoscopic endoluminal tracheal occlusion and reestablishment of fetal airways for congenital diaphragmatic hernia. Gynecol Surg 2018;15(01):9
2 Deprest JA, Nicolaides K, Gratacos E. Fetal surgery for congenital diaphragmatic hernia is back from never gone. Fetal Diagn Ther 2011;29(01):6–17
3 Baschat AA, Rosner M, Millard SE, et al. Single-center outcome of fetoscopic tracheal balloon occlusion for severe congenital diaphragmatic hernia. Obstet Gynecol 2020;135(03):511–521
4 Jani JC, Nicolaides KH, Gratacós E, Vandecruys H, Deprest JAFETO Task Group. Fetal lung-to-head ratio in the prediction of survival in severe left-sided diaphragmatic hernia treated by fetal endoscopic tracheal occlusion (FETO). Am J Obstet Gynecol 2006;195(06):1646–1650
5 Deprest JA, Benachi A, Gratacos E, et al; TOTAL Trial for Moderate Hypoplasia Investigators. Randomized trial of fetal surgery for moderate left diaphragmatic hernia. N Engl J Med 2021;385(02):119–129
6 Chen Y, Xu R, Xie X, Wang T, Yang Z, Chen J. Fetal endoscopic tracheal occlusion for congenital diaphragmatic hernia: systematic review and meta-analysis. Ultrasound Obstet Gynecol 2023;61(06):667–681

