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SFM Fetal Therapy Practice Guidelines: Fetoscopic Laser Photocoagulation in Monochorionic Twins

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Abstract

Fetoscopic laser coagulation is offered as a method of treatment for twin-to-twin transfusion syndrome or twin anemia polycythemia sequence. It involves laser ablation of intercommunicating superficial blood vessels on the surface of the placenta, under sono-endoscopic control. Preterm labor and preterm prelabor rupture of the membranes are known complications. The results depend on the expertise of the surgeon, location of the placenta, indication for treatment, severity of disease, and growth of babies. The chances of both babies surviving are around 65% and one baby surviving is 85%.

Keywords
- laser
- monochorionic twin
- twin-to-twin transfusion syndrome

Introduction

Fetoscopic laser photocoagulation (FLP) is a procedure used to treat complicated monochorionic (MC) twin pregnancy. It involves laser ablation of intercommunicating superficial blood vessels on the surface of the placenta, under sono-endoscopic control.

Indications

1. Twin-to-twin transfusion syndrome (TTTS) is the main indication for this procedure. It is performed at 16 to 26 weeks period of gestation for[1]:
   a. Quintero stage II-IV.
   b. In cases of Quintero stage I with short cervical length less than 25 mm or maternal debilitating symptoms because of polyhydramnios or changes in cardiac function in the recipient twin.
   The use of laser photocoagulation at more advanced gestational ages has technical limitations: suboptimal visualization due to fetal vernix in the amniotic fluid and larger placental vessels leading to difficulty in coagulation.
2. Selective fetal growth restriction (sFGR) type II or III
3. Twin anemia polycythemia syndrome (TAPS)

Contraindications

1. Preterm prelabor rupture of membranes
2. Preterm labor
3. Suspected abruption
4. Chorioamniotic separation
5. Demise of one twin
6. Chromosomal or congenital abnormalities in the twin

Maternal Risks

Laser therapy is relatively safe for the mother. Rare complications include:

1. Abdominal pain and peritoneal irritation due to leakage of blood or amniotic fluid in the abdominal cavity
2. Infection and chorioamnionitis
3. Abruptio placentae
4. Bleeding

In a systematic review and meta-analysis by Sacco et al, which included 6,746 women who underwent FLP, a severe complication occurred in 1.51% which included placental abruption (130), pulmonary edema (3), amniotic fluid embolism, and hemorrhage requiring delivery (2 each), maternal cardiac arrest and delivery by hysterotomy, lung collapse,

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disseminated intravascular coagulation and cesarean hysterectomy, and sepsis requiring delivery (1 each). Minor complications occurred in 4.03% which included bleeding during the procedure (148), chorioamnionitis (68), transfusion (9), pulmonary edema (11), venous thromboembolism (2), epidural headache, wound hernia and upper gastrointestinal bleed (1 each).[1,2]

Fetal Risks[2–4]

1. In utero death of one (30–40%) or both fetuses (12%).
2. Cerebral injury (cystic periventricular leukomalacia, intraventricular hemorrhage, posthemorrhagic ventricular dilatation, cerebral atrophy and arterial ischemic stroke) and long-term neurodevelopmental impairment. The incidence of neurologic morbidity at birth is about 11%.
3. Pseudo-amniotic band syndrome causing limb ischemia (1–2%)
4. Aplasia cutis and bowel atresia (rare)

Other Complications

1. Hematoma at the needle insertion site
2. Membrane separation at the site of trocar entry
3. Intra-amniotic bleeding due to vessel puncture on the placental surface accidentally
4. Iatrogenic septostomy due to inadvertent perforation of the twin's dividing membrane—cord entanglement, pseudo-amniotic band syndrome
5. Preterm prelabor rupture of membranes in up to 27% of cases
6. Spontaneous preterm labor—48%
7. Post-laser TAPS (2–13%)
8. Post-laser recurrent/persistent TTTS (0–16%)

Patient Information

1. What is TTTS and why it occurs?
   It is a complication of MC twin pregnancy, in which there is one placenta, which both babies share. There are vascular anastomoses in the placenta due to which there is ongoing flow of blood from one twin to another. An imbalance in this flow leads to more flow towards one fetus, which develops excessive liquor (recipient) and the other twin has decreased liquor (donor). As the disease progresses, other findings develop finally leading to the death of one or both twins. TTTS occurs in 10% of all MC twins.
2. How is it diagnosed and severity assessed?
   TTTS is diagnosed on ultrasonography (USG), when there is one placenta and increased fluid in the sac of one twin and decreased fluid in the sac of another twin. The severity is also classified on USG findings. The staging of TTTS is depicted in ►**Table 1**.
3. What happens without treatment?
   TTTS may remain stable or progress over time. In stage I, progression occurs in about 50%; however, in the rest of the cases, it is stable or regresses. Single-twin survival is 15 to 70% depending on stage and gestation at diagnosis. In stage III or higher, pregnancy loss occurs in 70 to 100%. Moreover, if one twin dies in utero, there is a 25% chance of the other twin dying and a 10 to 30% risk of neurological handicap in the surviving twin.
4. What is the treatment and how does it work?
   The treatment involves ablating the communicating vessels using a laser so that practically you make the placenta in two, each supplying one twin. It is done under USG and endoscopic guidance. This is similar to laparoscopy in adults. Under USG guidance, we introduce a trocar through the mother's abdomen into the sac of the baby with excessive fluid. Through this, a fetoscope carrying laser fiber is introduced. Through the fetoscope, we are able to see the communicating vessels on a TV screen and then under vision, the communicating vessels are ablated using the laser.
5. What are the chances of survival of babies after the procedure?
   There is evidence to show that laser improves the survival of babies and also survival with low chances of neurological damage. The results depend on the expertise of the surgeon, the location of the placenta, the severity of the disease, and the growth of babies. The chances of both babies surviving are around 65% and one baby surviving is 85%.
6. Any alternative treatment?[5]
   Serial amniocentesis is another option which includes removal of fluid from the pregnancy sac. The chances of survival of both twins are 35% and one twin is 70% with amnioreduction; this is lower than laser therapy. The chances of neurological damage at birth are higher with

Table 1 Quintero staging of TTTS

Stage	USG parameter	Categorical criteria
Stage 1	Maximum vertical pocket of amniotic fluid	Single vertical pocket of amniotic fluid $>$ 8 cm in recipient twin Single vertical pocket of amniotic fluid $<$ 2 cm in donor twin
Stage II	Fetal bladder	Bladder in donor twin is not seen during observation for 60 minutes
Stage III	Umbilical artery, ductus venosus and umbilical vein	Absent or reversed end diastolic flow in umbilical artery, reversed ductus venosus a wave and pulsatile flow in umbilical vein
Stage IV		Hydrops in one or both twins
Stage V		Fetal demise in one or both twins

Abbreviations: TTTS, twin-to-twin transfusion syndrome; USG, ultrasonography.

amniocentesis compared to laser therapy. This is generally reserved for cases coming after 26 weeks as laser is difficult in advanced gestation.

7. What are the complications of the procedure?
   Maternal complications—overall in about 2%
   a. Infection
   b. Bleeding
   c. Placental abruption
   d. Leakage of fluid/blood in the peritoneal cavity, causing irritation
   Fetal
   e. In-utero death of one (30–40%) or both fetuses (12%)
   f. Cerebral injury at birth—11%
   Others
   g. Preterm prelabor rupture of membranes in up to 25%
   h. Spontaneous preterm labor—48%
   i. Post-laser TAPS (2–13%)
   j. Post-laser recurrent/persistent TTTS (0–16%)
   k. Burn injury (rare)
   Long-term complications:

   As the procedure is associated with a high chance of preterm birth, depending on gestation at delivery, the baby may have problems associated with prematurity. Ten percent of babies may have neurological problems growing up, which could partly be because of TTTS per se and partly due to preterm birth.

sFGR

1. What is sFGR?
   This is another complication of MC twin pregnancy and occurs in 10 to 15%. Because of unequal placenta sharing one twin does not gain weight adequately. The condition is further complicated by communicating vessels. Some cases may show absent or reversed flow in the umbilical artery.
2. Is treatment necessary?
   There is a high chance of small twin deteriorating in utero, requiring very preterm delivery, before 30 to 32 weeks' gestation in majority. If a smaller twin dies in utero, the other twin also is at risk of dying or suffering neurological damage because of the flow of blood from the normal twin to the dying twin through communicating vessels. A laser will ablate these vessels, hence preventing complications in case one twin dies. This procedure has a high likelihood of small twin dying after the procedure.
3. What are alternative options?
   Pregnancy can be continued without intervention with the risks explained. Another option is the reduction of smaller twin using vaso-occlusive techniques. The chances of live birth of the remaining twin will be around 80%.

General Counseling Points

It is very difficult for the couple to understand and deal with the disease pathology and also, the emotional stress associated. Hence, preprocedure care and counseling have an important role in setting the expectations from the procedure. The couple should be counseled by a multidisciplinary team regarding the steps of the procedure and the postprocedure care. It is also considered prudent to answer any questions related to the procedure appropriately. Informed consent for the procedure is a must and should be taken after the counseling.

1. Explain about the need and rationale for doing the procedure.
2. Always explain regarding all the available treatment options.
3. Describe the procedure in brief and explain what to expect during the procedure.
4. Describe the maternal and fetal risks associated with the procedure.
5. Discuss the success and failure of the procedure and postoperative complications.
6. Describe the follow-up of pregnancy after the procedure.
7. Discuss the neonatal outcomes and long-term neurodevelopmental effects.

Counseling Statement for Medical Records

Should include:

1. USG findings and Quintero staging for TTTS.
2. Mention about growth and any coexisting congenital anomaly in either twin.
3. Treatment is indicated by staging and outcomes with and without treatment.
4. Common maternal and fetal complication.

Consent

I, ……., & my husband/family member ……(name and relation) have understood the condition (TTTS/ sFGR) that my unborn baby is suffering from, in detail. The expected progression of the problem, its likely consequences, and complications thereof as well as the various management options that are available to us at this gestational age were explained. The possible fetal interventions with the pros and cons of each and the costs involved were also discussed in detail. All possible complications to the mother and fetus were also explained in detail and include preterm delivery, premature membrane rupture, bleeding, infection, miscarriage and even fetal demise. We understand that the procedure will be performed under local/regional anesthesia with or without maternal sedation. Maternal risks and risks to the mother's life are therefore minimal but not nil. We accept the risks involved after fully understanding them and agree to go ahead with FLP of the placental anastomoses on our free will.

Patient's signatureHusband/Relative's signature
Date/timeDate/time

Preoperative Checklist and Patient Preparation

1. Detailed USG checklist:
   a. Diagnosis
   b. Mapping of placenta

   c. Location of intertwin membrane
   d. Identify the site for entry of instruments
2. Case record checklist:
   a. Comprehensive case review and detailed history
   b. Consent
   c. Relevant blood and urine investigations
3. Preanesthetic check-up and relevant investigations checklist: blood testing for complete blood count, type, liver function test, renal function test, coagulation profile, electrolytes
4. Preoperative medication checklist:
   a. Nil per oral for 8 hours
   b. One ringer lactate on the morning of surgery at the rate of 100 ml/hour (slow IV fluid)
   c. Antibiotic prophylaxis—1 g ceftriaxone or 2 g cefazolin 30 minutes before needle insertion
   d. IM micronized progesterone (100 mg) on the day of surgery
   e. Tablet nifedipine 10 mg stat 30 minutes before the procedure for tocolysis or tablet indomethacin orally 50 mg every 6 hours started 12 hours before or NTG transdermal patch 1 hour before the procedure
   f. After 24 to 26 weeks of gestation, a course of antenatal corticosteroids is administered in case of preterm delivery after consultation with a neonatologist.

Personnel Required

1. Operator: Trained in USG and endoscopic-guided procedures
2. Assistant trained in deploying the equipment or handling the USG probe
3. Circulating nurse to set tray and provide things
4. Sonographic assistant to handle USG machine
5. Anesthetists for sedation/regional anesthesia

Operating Room Requirement

The procedure may be performed in an operation theatre as a daycare procedure under IV sedation and strict aseptic conditions. A good resolution color Doppler USG machine is mandatory.

Equipment Checklist

1. USG machine
2. Endoscopy setup including camera, image processor, light source, and monitors
3. Fetoscope
   - 2.9 mm diagnostic 30-degree forward oblique for mapping
   - Integrated scope consisting of 2 mm telescope + operating channels
   - For procedures < 19 weeks, use integrated 1.2 mm scope
4. Laser machine set at power 30 to 40 W with foot switch control
5. Disposable laser fiber with connector, 400 or 600 microns

Details of Laser:

The following criteria should be met in order to use laser energy for FLP:

- Appropriate wavelength selection with absorption peak for hemoglobin (target tissue in blood vessels)
- Selectivity of target tissue to reduce the damage to surrounding tissue
- Low diffusion and high thermal conversion with a focus on target tissue with minimal damage to surrounding tissues
- Minimal absorption of water that will ensure safety during the procedure by preventing excessive heating of amniotic fluid
- Fiber optic compatibility: It allows the laser beam to be delivered precisely to the target area through a flexible endoscope

Currently, two lasers exist which are compatible with the above criteria:

1. Neodymium-yttrium aluminum garnet laser (1,064 nm)
2. Diode laser (940 nm)—closer to the hemoglobin absorption spectrum, used more commonly due to its smaller size and lower cost
   The therapeutic efficacy of both lasers is equivalent.
3. Vacuum aspirator
4. Fluid infuser (if available)
5. Sterile covers for camera, USG probe
6. Infusion set, aspiration set
7. 50 cc syringes
8. Sterile sample tube for amniotic fluid (if sample needed)
9. Standard universal sets for operative site disinfection and sterile draping
10. 11-blade scalpel for initial incision
11. 18 G needle for primary entry into the uterus
12. Single-use introducer sheath set (10 Fr) or reusable metal trocar (3 mm)
13. Warmed normal saline for amnioinfusion if needed
14. Rapid Vicryl 3-0 for skin
15. Surgical dressing

Anesthesia

Local anesthesia: 1% lignocaine. Intravenous sedation (midazolam) can be considered if required.

Spinal/epidural anesthesia can be given in patients with a short cervix who will simultaneously require a cervical cerclage to be placed

Procedure Steps[6]

Patient Position

The patient should be positioned in such a way that an ideal entry site can be obtained for adequate visualization and laser firing angle.

- Vertical anterior equator: The patient is positioned completely on her side

- Horizontal or transverse equator: The operator can stand in between the legs.

Screen placement: The screens should be positioned opposite the operators. This ensures that the operators have a clear view of the procedure on the screen, facilitating precise and safe execution.

1. Disinfect the skin and cover it with sterile drapes.
2. Identify the point of entry. Doppler may be used to locate an avascular area in the uterine wall. The basic principle of the point of entry is:
   a. Scope insertion in the recipient sac: The scope should be inserted into the recipient sac. It is crucial that the direction of insertion is perpendicular to the inter-twin membrane (corresponding to a virtual line drawn between the two cord insertions, previously assessed) and, as a result, perpendicular to the lie of the donor twin. The purpose of such an entry is to enable easy access to the entire membrane length along the chorionic plate.
   b. Avoidance points: Avoid entry at the points of:
      - Superficial epigastric vessels
      - Deep uterine vessels

   Position for insertion of scope: To prevent injury to the vessels mentioned above, the scope should be inserted in either the midline region or the lateral region of the abdomen. These regions offer a safer path for insertion, minimizing the risk of vessel damage.
3. Infiltrate local anesthesia:
   The point of entry should be infiltrated with local anesthesia (subcutaneous infiltration of 1% lignocaine). The depth of this should be controlled under USG.
4. Make a small skin incision (3 mm to 1 cm) to allow smooth trocar introduction. Under USG guidance, the trocar and cannula are inserted into the amniotic cavity of the twin with polyhydramnios.
   Another technique: Seldinger-technique
   - Introduce a needle in the amniotic cavity.
   - Thread the spring wire:
   - Thread it through the needle in a manner that allows you to adjust approximately one-third of its length to remain outside the abdomen.
   - Remove the needle
   - Thread the sheath along with a rigid introducer onto the spring wire and apply gentle pressure to push it into the amniotic cavity.
   - Once inside the cavity, withdraw the introducer and guidewire.
   - Although the preference is mostly operator-dependent, this method may be more useful in cases with sFGR and TAPS. Moreover, there is no evidence that the outcomes of one or the other entry technique are better.
5. After the placement of the sheath, the amniotic fluid sample can be collected if indicated and if the patient has given consent for genetic testing. First, aspirate and discard the first 5 to 10 mL of fluid from the irrigation channel of the sheath. Following that, aspirate around 20 cc of fluid.
6. Choose and insert fetoscope: Choose a fetoscope of 1 to 2 mm diameter and insert it through the sheath/cannula into the amniotic cavity.
7. Connect the fetoscope to the camera system: Connect the lens system of the fetoscope to a high-definition camera system with recording capabilities. Use a cold light source (Xenon) to provide neutral-tone lighting. Use sterile polythene covers with connectors for the camera and light source cables to maintain sterility.
8. Advance the fetoscope: Advance the fetoscope through the cannula to overlook the surgical field.
9. Improve visibility: Infuse warm lactated Ringer's solution through the working channel or cannula to improve visibility.
10. Identify the landmarks, including the insertion of the two umbilical cords, the inter-twin membrane insertion, and the vessels on the surface of the placenta connecting the two fetuses. Sometimes, identifying the vascular equator can be a tedious task as it could have been pushed towards the donor sac by the excessive liquor of the recipient sac. Thus, the vascular equator is not always identified at the same level as the inter-twin membrane. Identifying features include:
    - The membranous equator appears as a white line over the placenta.
    - Veins and arteries are easily distinguished by their color as in utero veins have a more typical red (oxygenated) color while arteries are darker (deoxygenated blood).
    - If color differentiation cannot be easily discerned, a vessel can be traced back to its origin from the cord insertion into the placenta. Also, placental arteries are noted to cross over placental veins.
11. Prepare the laser fiber: Pass the laser fiber (600 µm or 400 µm) through the operating channel of the fetoscope, with a side-firing configuration. The laser machine should be configured to produce 40 watts of power, but keep it unarmed unless the operators have completed a primary identification of important landmarks.
12. Coagulate the anastomoses of the vessels—Apply laser energy (20 to 40 watts), maintaining a 1 cm distance between fiber and tissue and avoiding direct contact. Coagulate the vessel by firing the bursts of energy over 3 to 4 seconds. As a sign of successful coagulation, the vessels and amnion will turn white. Coagulate the anastomotic vessels in a specific sequential sequence (called sequential selective laser photocoagulation): Arteriovenous (donor artery to recipient vein), then venousarterial (donor vein to recipient artery), and lastly arterial-arterial and venous-venous anastomoses. In addition, after coagulation of all visible anastomoses, coagulate a thin line of the placental surface at the vascular equator leads to equatorial dichorionization. In the case of larger vessels (> 3mm), one might need to apply energy multiple times along the course of the vessel and it is preferred to perform the coagulation starting from the edges to center of the vessel.

13. Confirm coagulation completeness: Perform a final check to confirm the completeness of coagulation. Coagulate any missed vessels before concluding the procedure.
14. Drain amniotic fluid: Use a sterile tube connected to the fluid channel of the sheath and an electric suction machine to drain amniotic fluid until single vertical pocket (SVP) reaches 5 to 6 cm or a maximum of 3 liters. This procedure in itself improves the blood flow to the placenta by reducing hydrostatic pressure on the placenta and cervix. As a consequence, the rate of preterm labor may be reduced. Also, it may also reduce the chances of leakage of amniotic fluid into the peritoneal cavity of the patient.
15. Remove fetoscope and sheath: Remove the fetoscope after confirming the coagulation is complete and amniotic fluid, if required, has been drained. Introduce the rigid introducer into the sheath and under USG guidance, remove the sheath in a brisk motion in order to avoid trauma to the membranes.
16. Check cardiac activity in both twins
17. Close the skin incision with a single stitch using absorbable sutures.
18. Special situations:
    (a) Anterior placenta
        - In order to have an optimal vision of the placenta, a curved fetoscope model could be used in place of the straight scope.
        - In order to further optimize the angle, the extreme lateral tilt position of the patient can be chosen and thus, the maximum lateral can be chosen for insertion.
        - Deflecting mechanisms to enable the operator to deflect the laser fiber to the target could be used. A 30 degrees (rod lens) fetoscope is an example of this.

    (b) Cases in which the vascular equator is extending to the donor twin sac.

    Based on the extent of the anastomoses in the donor sac, it can be managed in two ways.

    (1) If the anastomoses are close to the membrane insertion and seen from the recipient sac, transmit the laser beam through the avascular membrane as it will not absorb the laser energy and can easily target the anastomosis from the recipient sac itself.

    (2) If the anastomoses are beyond the reach of such laser treatment, use the laser fiber as a guidewire and exert a sharp push using it. Carefully, then insert the rest of the fetoscope and complete the coagulation process.

Postoperative Checklist

1. Document the fetal heart activity of both twins and also show it to the patient at the end of the procedure. Also, document the single largest pocket of amniotic fluid for both the fetuses.
2. The patient is observed in the operation theater recovery area for 2 hours after which she can be shifted to the ward. If the woman is Rh negative (nonisoimmunized), an anti-D 300 ug is to be given.
3. An USG scan after 24 hours is done to assess possible complications such as fetal demise, occurrence of inadvertent septostomy or membrane separation and cervical length. Doppler of the umbilical artery (UA), middle cerebral artery (MCA) and ductus venosus (DV) is done for both fetuses.
4. If no complaints from the patient, she is allowed to go home 24 to 48 hours postprocedure, with the following advice:
    a. Avoid overstraining/lifting heavy weights for a week
    b. Report to the hospital immediately if there is substantial leaking, bleeding, pain, generalized feeling of unwellness or fever
    c. May continue vaginal micronized progesterone till 36 weeks
5. Detailed procedure report and follow-up plan are generated and one copy is handed over to the patient at the time of discharge.

    The patient is followed on an outpatient department basis for monitoring by USG weekly/ biweekly

    (a) Reassessment of TTTS staging for progression or regression—SVP of amniotic fluid, donor bladder visualization, Doppler flow assessment of UA and DV.

    (b) Measurement of MCA-PSV and calculation of the multiple-of-median values – for evolving TAPS.

    (c) Fetal growth and well-being

Invasive Report Template

Patient name
Age
Hospital ID
Contact number
Obstetric history: G P A L; Type of conception:;
Consanguineous:
Gestational age at diagnosis
Indication
Procedure name
Maternal anesthesia
Starting number of fetuses:
Uterine entry: Midline, right/left, upper/lower quadrant
No of attempts: Single/double/multiple
Amnioreduction: Yes/no
Cerclage: Yes/no
Intraoperative complications:
Finishing number of fetus:
Postprocedure cardiac activity (immediately):
Postprocedure cardiac activity and MCA-PSV in both twins (24 hr):
Postoperative advice:
Postprocedure MRI (after 4–6 weeks):

Conflict of Interest
None declared.

Acknowledgment
None.

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