Changing Landscapes of In Utero Minimally Invasive Surgical Interventions

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The beginning of modern fetal medicine started with the advent of an ultrasound machine. The imaging technologies have been continuously improving, and it lends a tremendous help to the understanding of the fetal condition and intrauterine environment. Molecular genetics additionally improve the ability to diagnose various fetal diseases, at an earlier gestational age.[1] Medical treatments have been partially successful to salvage some fetuses. Ultrasound guided procedures, such as an intraumbilical blood transfusion, have also become a standard of treatment in many fetal conditions.[2]

Operative fetoscopy has primarily been developed as a technique to sample fetal blood from the chorionic plate vessels.[3] It has subsequently been replaced with the ultrasound guided percutaneous fetal blood sampling, although the development of fetoscopy has not ceased. The addition of fluid and instrumental channels to the side ports, along with the reduction in the caliber of the lenses, made the operative fetoscopy gain its popularity once again.[4] Most of the interventions are now reduced to the placental and umbilical cord surgery in monochorionic twin pregnancies. Umbilical surgeries could also be accomplished using an ultrasound guided diathermy[5]. In this review, the discussion involving the indications and technical challenges of fetoscopic intervention will be elaborated.

Twin-twin transfusion syndrome

Approximately 15% of monochorionic twins will be affected with twin-twin transfusion syndrome (TTTS).[6] This emphasizes the importance of chorionicity determination during the scan for multifetal gestations. If the disease develops early, and is left untreated, it will result in almost the virtual demise of at least 1 fetus. Prematurity, with the average gestational age at delivery of 27 weeks, is responsible for the neonatal death and long term neurological deficit.[7] Fetal intervention is indicated. Serial amniodrainage to relieve the pressure can prolong pregnancy to the median gestational age of 30 weeks, with the average neonatal survival of at least 1 fetus of 72%. This intervention, however, does not correct the underlying ever present placental vascular connections, therefore, both fetuses are still at a 22% risk of being affected with cerebral palsy at birth.[7]

Laser photocoagulation of the anastomosing chorionic vessels has recently been accepted as the most effective way to treat TTTS.[8] Our team have experiences with fetoscopy for diagnostic purposes since the year 1987.[9] After the remarkable developments of endoscopic tools and the optimization of surgical techniques, the therapeutic procedures were subsequently available. For the treatment of TTTS, the anastomosing vessels are easily visualized on the chorionic plate, and are the target for coagulation, as seen in Figure 1 and 2. Technical considerations by our team have been described elsewhere.[10] Milestone surgical techniques to optimize the outcomes that have been reported lately include the selective coagulation of only the anastomoses on the vascular equator, and not all the vessels traversing the intertwin membranes and the sequential coagulation.[11, 12]

With the current approach, the chance of getting at least one baby surviving through the neonatal period is as high as 85%. The "dichorionization" of the placental mass allows for both fetuses to grow separately. This remarkably reduces the cerebral palsy rate to 3-5%. It is

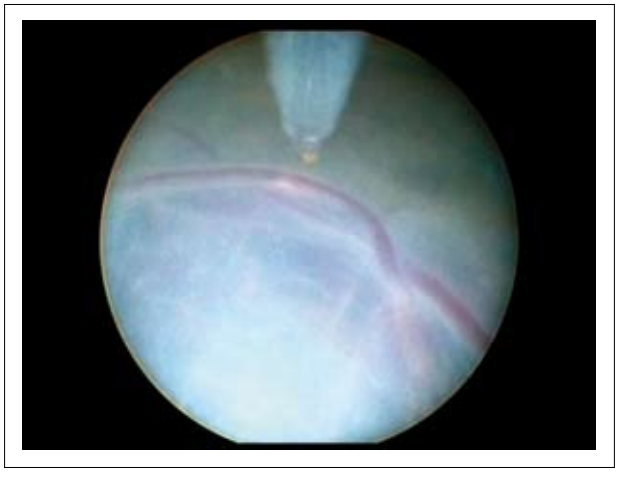

Fig 1. Chorionic plate vessels seen from the operative fetoscopy. Note the artery running on top of the vein.

Fig 2. Selective and sequential coagulation starts from coagulation of the artery of the donor. With this approach, interfetal bleeding could be reduced.[13]

Fig 3. Umbilical cord coagulation with bipolar diathermy in the discordant anomalous monochorionic twins at 18 weeks'. Note the Power Doppler signal in orange, indicating the flow within the umbilicalcord.

also partially the result of a longer median gestational age at delivery, 33.5 weeks'.[4]

Selective feticide in monochorionic twins

Some monochorionic twin pregnancies are complicated by conditions that do not allow for the development of one of the fetuses. Such conditions include acardiac twins (twins reverse arterial perfusion/TRAP sequence), selective growth restriction in TTTS, and severe TTTS. Discordant malformations in monochorionic twins from postzygotic mutation could also be encountered. These conditions are a challenge in the way that if the abnormal fetus dies in utero, there could be serious consequences to the living fetus. Since the dead fetus has no blood pressure, blood from the living fetus could drain to these nonviable vascular channels. Fetal exanguination could result in cerebral damages in the living fetus, or worse, fetal demise.

Or on the other way around, if the both normal and abnormal fetuses keep growing, premature labor could happen. This could jeopardize the outcome of the healthy fetus. Selective feticide with a substance causing cardiac asystole, such as potassium chloride or lidocaine, is contraindicated in this situation, owing to the risk of dual demises.

Umbilical cord interruption has emerged as a technique to selectively terminate one fetus without an effect to the others. Several techniques have been described, including bipolar coagulation, cord ligation with an extracorporeal knot pusher, laser ablation directly at the umbilical cord or at the chorionic vessels.[14] Bipolar umbilical cord diathermy seems to be the most effective of all in managing this rare, but lethal, condition. It results in an 80% survival rate, with 67% of the pump fetus delivered after 36 weeks' period.[15] We have embraced the use of bipolar cord coagulation in the year 2008, as an alternative technique to manage complicated monochorionic twin pregnancies, as shown in Figure 3. We have also expanded its application to feticide in the fetus affected with malformations that can cause severe handicap, where the couple decided to have pregnancy termination at a borderline viable gestational age.

Other potential usefulness of fetoscopic interventions

Even though the technical development is still ongoing, in utero placental and umbilical cord surgeries have been performed all around the globe, with comparable perinatal outcomes.[16,17] On the other hand, the procedures performed on the fetus are yet to be optimized. The most widely studied is the fetal tracheal occlusion as a treatment for congenital diaphragmatic hernia.[18,19] Other case reports include the treatment of severe fetal aortic valve obstruction[20], lysis of the amniotic band[21], ablation of the posterior urethral valve[22], ablation of sacrococcygeal teratoma[6], and synthetic mesh closure of fetal spina bifida.[23]

Limitation of minimally invasive fetal surgeries

Aside from the general perioperative complications, rupture of the fetal membranes is still the major drawback of the fetal surgeries. The estimated incidence is 5-8% for the modern fetoscopic interventions.[24] Resealing the membranes defect with amniopatch have been undergoing an intense investigation, but with a modest success.[25]

CONCLUSION

Surgical techniques of the fetal interventions are still evolving. This gives hope to the parents whose fetuses are affected by the diseases once deemed unsalvageable. These procedures, however, are not without risks. Until the perfect strategies are developed, the hopeful parents should be fully counseled by the specialists and multidisciplinary team. Psychological support is also of tremendous importance.

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REFERENCES

1. Watagana T, Bianchi DW. Fetal cell-free nucleic acids in the maternal circulation: new clinical applications. Ann N Y Acad Sci 2004;1022:90-99.
2. Watagana T, Wiwanichayakul B, Ruengwuttilert P, Sunsaneevithayakul P, Viboonchart S, Wantanasiri C. Noninvasive diagnosis of fetal anemia and fetal intravascular transfusion therapy: experiences at Siriraj Hospital. J Med Assoc Thai 2006;89:1036-43.
3. Rodeck CH, Wass D. Sampling pure fetal blood in twin pregnancies by fetoscopy using a single uterine puncture. Prenat Diagn 1981;1:43-49.
4. Deprest J, Jani J, Lewi L, et al. Fetoscopic surgery: encouraged by clinical experience and boosted by instrument innovation. Semin Fetal Neonatal Med 2006;11:398-412.
5. Taylor MJ, Shalev E, Tanawattanacharoen S, Jolly M, Kumar S, Weiner E, et al. Ultrasound-guided umbilical cord occlusion using bipolar diathermy for Stage III/IV twin-twin transfusion syndrome. Prenat Diagn 2002;22:70-76.
6. Danzer E, Sydorak RM, Harrison MR, Albanese CT. Minimal access fetal surgery. Eur J Obstet Gynecol Reprod Biol 2003;108:3-13.
7. Matsuda Y, Kouno S. Fetal and neonatal outcomes in twin oligohydramnios-polyhydramnios sequence including cerebral palsy. Fetal Diagn Ther 2002;17:268-71.
8. Roberts D NJ, Kilby M, Gates S. Interventions for the treatment of twin-twin transfusion syndrome. Cochrane Database of Systematic Review 2007, Issue 4. Art. No.:CD002073. DOI: 10. 1002/14651858. CD002073. pub 3 2007.
9. Kanokpongsakdi S, Winichagoon P, Fucharoen S, Manassagorn J. Prenatal diagnosis of the fetus at risk for beta-thalassemia/hemoglobin E disease: a report of the first case in Thailand. J Med Assoc Thai 1987;70:38-43.
10. Watagana T, Chanprapaph P, Chuangsuwanich T, Kanokpongsakdi S, Chuenwattana P, Titapant V. Reverse twin-twin transfusion syndrome after fetoscopic laser photocoagulation of chorionic anastomosis: a case report. Fetal Diagn Ther 2008;In press.
11. Quintero RA, Morales WJ, Mendoza G, Allen M, Kalter CS, Giannina G, et al. Selective photocoagulation of placental vessels in twin-twin transfusion syndrome: evolution of a surgical technique. Obstet Gynecol Surv 1998;53:(12 Suppl):S97-103.
12. Sepulveda W, Wong AE, Devoto JC, Alcalde JL. Endoscopic laser surgery in severe second trimester twin-twin transfusion syndrome: a three-year experience from a Latin American center. Prenat Diagn 2007;27:1033-8.
13. Van Gemert MJ, Van Den Wijngaard JP, Lopriore E, Lewi L, Deprest J, Vandenbussche FP. Simulated sequential laser therapy of twin-twin transfusion syndrome. Placenta 2008;29:609-13.
14. Lewi L, Gratacos E, Ortibus E, Van Schoubroeck D, Carreras E, Higueras T, et al. Pregnancy and infant outcome of 80 consecutive cord coagulations in complicated monochorionic multiple pregnancies. Am J Obstet Gynecol 2006;194:782-9.
15. Diehl W, Hecher K. Selective cord coagulation in acardiac twins. Semin Fetal Neonatal Med 2007;12:458-63.
16. Chang YL. Fetoscopic laser therapy for twin-twin transfusion syndrome. Taiwan J Obstet Gynecol 2006;45:294-301.
17. Said S, Flood K, Breathnach F, Fleming A, Kinsella CB, Geary M, et al. Fetoscopic laser treatment of twin-to-twintransfusion syndrome (TTTS). Ir Med J 2008;101:191-3.
18. Peralta CF, Jani JC, Van Schoubroeck D, Nicolaides KH, Deprest JA. Fetal lung volume after endoscopic tracheal occlusion in the prediction of postnatal outcome. Am J Obstet Gynecol 2008;198:e1-e5.
19. Saura L, Castañón M, Prat J, Albert A, Caceres F, Moreno J, et al. Impact of fetal intervention on postnatal management of congenital diaphragmatic hernia. Eur J Pediatr Surg 2008;17:404-7.
20. Kohl T, Sharland G, Allan LD, Gembruch U, Chaoui R, Lopes LM, et al. World experience of percutaneous ultrasound-guided balloon valvuloplasty in human fetuses with severe aortic valve obstruction. Am J Cardiol 2000;85:1230-3.
21. Quintero RA, Morales WJ, Phillips J, Kalter CS, Angel JL. In utero lysis of amniotic bands. Ultrasound Obstet Gynecol 1997;10:316-20.
22. Quintero RA. Fetal obstructive uropathy. Clin Obstet Gynecol 2005;48:923-41.
23. Pedreira DA, Oliveira RC, Valente PR, Abou-Jamra RC, Araujo A, Saldiva PH. Gasless fetoscopy: a new approach to endoscopic closure of a lumbar skin defect in fetal sheep. Fetal Diagn Ther 2008;23:293-8.
24. Quintero RA. New horizones in the treatment of preterm premature rupture of membranes. Clin Perinatol 2001;28:861-75.
25. Quintero RA, Kontopoulos EV, Chmait R, Bornick PW, Allen M. Management of twin-twin transfusion syndrome in pregnancies with iatrogenic detachment of membranes following therapeutic amniocentesis and the role of interim amniopatch. Ultrasound Obstet Gynecol 2005;26:628-33.