Percutaneous Fetoscopic Spina Bifida Repair

Prenatal open spina bifida repair (OSB) via the percutaneous fetoscopic approach does not require maternal laparotomy, hysterotomy, or exteriorization of the uterus. This technique does require intrauterine partial carbon dioxide (CO2) insufflation (PACI).

Prenatal surgery for spina bifida via open fetal surgery with hysterotomy decreases the rate of ventriculoperitoneal shunt placement and improves motor function compared to standard postnatal surgery. Maternal risks of open fetal surgery are primarily related to complications of the hysterotomy including thinning or rupture that begins in the index pregnancy but persists for every future pregnancy. Minimizing maternal risks is the largest impetus to explore and optimize a minimally invasive fetoscopic alternative. Techniques vary from using a complete percutaneous approach to open fetoscopy, which requires laparotomy but is minimally invasive to the uterus. This allows vaginal delivery at term and no scar complications are reported thus far. Fetal short-term neurosurgical outcomes compare favorably with improvement in hindbrain herniation >70% and decreased need for treatment for hydrocephalus between 40-45% after prenatal surgery performed either fetoscopically or through open fetal surgery [1)].

The fetoscopic procedure takes about 2.5 hours. A general anesthetic is first given to the mother. That anesthetic relaxes the uterus and the fetus before the fetus receives intramuscular pain medication. Carbon dioxide is inserted into the uterus to improve visualization of the spinal defect. The repair is performed by inserting 2-millimeter instruments through tiny ports.

The Management Of Myelomeningocele Study (MOMS) trial demonstrated the safety and efficacy of open fetal surgery for spina bifida (SB). Developed alternative techniques may reduce maternal risks yet should do without compromising on fetal neuroprotective effects.

Joyeux et al., searched Medline, Web of Science, Embase, Scopus, and Cochrane databases and the grey literature to identify relevant articles without language restriction from January 1980 until October 2018. They systematically reviewed and selected studies reporting all consecutive procedures and with a postnatal follow-up ≥12 months. They also had to report outcome variables necessary to measure the learning curve defined by fetal safety and efficacy. Two independent authors retrieved the data, assessed the quality of the studies, and categorized observations into blocks of 30 patients. For the meta-analysis, data were pooled using a random-effects model when heterogeneous. To measure the learning curve, we used two complementary methods. With the group splitting method, competency was defined when the procedure provided comparable results to the MOMS trial for 12 outcome variables representative for (1) the immediate surgical outcome, (2) short-term neonatal neuroprotection, and (3) long-term neuroprotection at ≥12 months. Then, when the patients' raw data were available, they performed cumulative sum (CUSUM) analysis based on a composite binary outcome defining a successful surgery. It combined four clinically relevant variables for safety (fetal death within 7 days) and for efficacy (neuroprotection at birth).

They included 17/6024 (0.3%) studies with low and moderate risks of bias. Fetal SB closure was performed via standard-hysterotomy (n=11), mini-hysterotomy (n=1) or fetoscopy [exteriorized-uterus single-layer (n=1), percutaneous single-layer (n=3) or percutaneous two-layer closure (n=1)]. Only outcomes for the standard-hysterotomy could be meta-analyzed. Overall, outcomes significantly

improved with experience. Competency was reached after 35 consecutive cases for standard-hysterotomy and was predicted to be achieved after ≥57 cases for mini-hysterotomy and ≥56 for percutaneous two-layer fetoscopy. For percutaneous and uterus-exteriorized single-layer fetoscopy, competency was not respectively reached by cases 81 and 28 available for analysis.

The number of cases operated correlates with the outcome of SB fetal closure and ranges from 35 cases for standard-hysterotomy to ≥56-57 cases for minimally invasive modifications. The observations provide important information for institutions eager to establish a new fetal center, develop a new technique or train their team, and inform referring clinicians, potential patients and third-parties [2)].

Case series

In a prospective study from Los Angeles of patients who underwent percutaneous fetoscopic OSB repair from 2/2019 to 7/2020. Fetal cordocentesis of the umbilical vein was performed in cases with favorable access to the umbilical cord. The umbilical vein cord blood samples were obtained under ultrasound guidance immediately at the conclusion of the OSB repair. Simultaneous maternal arterial blood gas samples were also obtained. Results are reported as median (range).

Of 20 patients who underwent percutaneous fetoscopic OSB repair during the study period, 7 patients (35%) underwent fetal blood sampling. Gestational age at time of surgery was 27.4 (24.0 - 27.9) weeks and operative time was 183 (156 - 251) minutes. The CO2 exposure time was 122 (57 - 146) minutes with maximum pressure of 13.5 (12.0 - 15.0) mmHg. Fetal umbilical vein results were: pH 7.35 (7.30 - 7.39), pO2 56.2 (47.1 - 99.9) mmHg, pCO2 43.8 (36.2 - 53.0) mmHg, HCO3 23.9 (20.1 - 25.6) mmol/L and base excess (BE) -2.2 (-4.5 to -0.4) mmol/L. Simultaneous maternal arterial blood gas results were: pH 7.37 (7.28 - 7.42), pO2 187.5 (124.4 - 405.2) mmHg, pCO2 36.6 (30.7 - 46.0) mmHg, HCO3 21.3 (18.0 - 22.8) mmol/L and BE -3.2 (-5.9 to -1.8) mmol/L.

Despite prolonged Carbon dioxide insufflation of the uterus, fetal umbilical vein pH and base excess values did not approach those associated with potentially pathologic fetal acidemia [3)].

Surgery was performed between 24.0 and 28.9 gestational weeks with the woman under general anesthesia, using an entirely percutaneous fetoscopic approach with partial carbon dioxide insufflation of the uterine cavity, as described previously. If there was enough skin to be sutured in the midline, only a biocellulose patch was placed over the placode (single-patch group). In cases in which skin approximation was not possible, a bilaminar skin substitute (two layers: one silicone and one dermal matrix) was placed over the biocellulose patch and sutured to the skin edges (two-patch group). The surgical site was assessed at birth, and long-term follow-up was carried out.

Results: Percutaneous fetoscopic OSB repair was attempted in 47 consecutive fetuses, but surgery could not be completed in two. Preterm prelabor rupture of membranes (PPROM) occurred in 36 of the 45 (80%) cases which formed the study group, and the mean gestational age at delivery was 32.8 ± 2.5 weeks. A bilaminar skin substitute was required in 13/45 (29%) cases; in the remaining 32 cases, direct skin-to-skin suture was feasible. There were 12 cases of myeloschisis, of which 10 were in the two-patch group. In all cases, the skin substitute was located at the surgical site at birth. In five of the 13 (38.5%) cases in the two-patch group, additional postnatal repair was needed. In the remaining

cases, the silicone layer detached spontaneously from the dermal matrix (on average, 25 days after birth), and the lesion healed by secondary intention. The mean operating time was 193 (range, 83-450) min; it was significantly longer in cases requiring the bilaminar skin substitute (additional 42 min on average), although the two-patch group had similar PPROM rate and gestational age at delivery compared with the single-patch group. Complete reversal of hindbrain herniation occurred in 68% of the 28 single-patch cases and 33% of the 12 two-patch cases with this information available ($P < 0.05$). In four cases there was no reversal; half of these occurred in myeloschisis cases.

Conclusions: Large OSB defects may be treated successfully in utero using a bilaminar skin substitute over a biocellulose patch through an entirely percutaneous approach. Although the operating time is longer, surgical outcome is similar to that in cases closed primarily. Cases with myeloschisis seem to have a worse prognosis than do those with myelomeningocele. PPROM and preterm birth continue to be a challenge. Further experience is needed to assess the risks and benefits of this technique for the management of large OSB defects [4)].

1)
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