69 Amnioinfusion

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INTRODUCTION

Amnioinfusion is a technique in which a crystalloid solution, usually normal saline, is instilled into the amniotic cavity to replace amniotic fluid, which may be absent or low. This technique has been employed with increasing frequency and interest during the past three decades. It is used most often during the intrapartum period to prevent, decrease, or eliminate variable decelerations (1–5). During the antepartum period, amnioinfusion is used less frequently. It is mainly used in this setting to facilitate evaluation of fetal anatomy, less commonly in attempts to reduce fetal complications from prolonged oligohydramnios, and rarely to prevent infectious complications from preterm premature rupture of the membranes (PROM) (6–10).

PATHOGENESIS AND CLINICAL ASPECTS OF OLIGOHYDRAMNIOS

Near the end of the first trimester, the amnion and chorion fuse to create the amniotic cavity, which contains approximately 50 mL of amniotic fluid. In early pregnancy, the amniotic fluid is primarily the product of maternal transudate through the amniotic membranes. By the 16th week of gestation, the amniotic fluid volume is mainly regulated by the processes of fetal urination and fetal swallowing. As the pregnancy progresses, the normal amniotic fluid volume rapidly increases to a maximum (range 0.5–2.0 liters, 95% confidence interval) at about 34 weeks of gestation. The volume then normally decreases as a natural progression (11).

Oligohydramnios can result from

1. any condition that prevents the formation of urine or prevents the entry of urine into the amniotic sac, including bilateral renal agenesis, bilateral multicystic dysplastic kidneys, infantile polycystic kidney disease, and complete lower tract obstructive uropathies;
2. uteroplacental insufficiency, particularly in the setting of fetal growth restriction (FGR);
3. post-term pregnancies;
4. rupture of membranes (ROM);
5. prolonged maternal use of indomethacin or other nonsteroidal anti-inflammatory drugs;
6. abdominal pregnancy; and
7. reasons unknown, that is, idiopathic.

The amniotic fluid environment is necessary for normal fetal growth and development, as evidenced by fetal lung hypoplasia and deformations in the case of Potter's syndrome. Pulmonary hypoplasia may well develop if prolonged oligohydramnios (>2 weeks) secondary to preterm PROM occurs prior to 24 weeks of gestation. The earlier the

gestational age when the premature ROM occurs, the greater the incidence of lung hypoplasia (12). Oligohydramnios predisposes to umbilical cord compression, which can lead to fetal hypoxia if resultant interference with blood flow is severe, repetitive, and prolonged.

Clinical management involves obtaining a patient's history to determine:

1. leakage of amniotic fluid;
2. risk factors for FGR such as smoking, drug abuse, severe diabetes, or cardiovascular disorders;
3. medication history; and
4. family history of congenital anomalies, especially urinary tract abnormalities.

Physical examination may reveal the fundal height to be less than expected, leakage of amniotic fluid from the cervical canal, and/or positive tests for ROM. Fetal heart rate monitoring may reveal variable or prolonged decelerations.

Ultrasound evaluation is essential in assessing the amniotic fluid volume and fetal anatomy. Occasionally, amniocentesis with injection of indigo carmine dye may be necessary to diagnose ROM, especially when there is a history of leakage of fluid in the absence of confirmatory findings.

Ultrasound evaluation of the amniotic fluid includes the one largest vertical pocket and the amniotic fluid index (AFI). The latter is a summation of the highest vertical dimensions of the four quadrants of the uterine cavity. Oligohydramnios exists if the AFI is less than 5 cm. If the vertical dimension of the largest pocket of fluid is <1 cm, severe oligohydramnios is present.

The initial step in the clinical management of oligohydramnios is to determine the etiology. Management is then based on gestational age, maternal health, fetal diagnosis and prognosis, and the patient and family's concerns.

INDICATIONS FOR AMNIOINFUSION

General Overview

Amnioinfusion is generally classified according to the pregnancy status as antepartum or intrapartum. The procedure is performed either transcervically or transabdominally. Its purpose can be diagnostic, therapeutic, or prophylactic.

During the antepartum period, amnioinfusion may be used transabdominally to improve sonographic imaging, to obtain fluid for culture, to obtain fetal cells for karyotyping, and to restore adequate levels of fluid to reduce the likelihood of lung hypoplasia and arthrogryposis.

During the intrapartum period, amnioinfusion may be diagnostic (instilling and aspirating fluid to evaluate the microbiology of in utero infections), therapeutic (to alleviate cord compression), or prophylactic (selected cases to decrease the incidence of meconium aspiration syndrome).

Antepartum Indications: Diagnostic

Oligohydramnios poses a diagnostic challenge for the physician, as the differential diagnosis is broad. Etiologies may include urethral outflow obstruction, absent or diminished renal function, PROM, FGR, congenital malformations, or chromosome anomalies. Conventional sonographic imaging may prove inadequate to view the fetal anatomy, owing to the absence of a satisfactory acoustic window. Fetal positioning, including crowding of small parts, may also impair visualization. Therefore, diagnostic imaging is an important step prior to selecting a course of therapy.

In 1988, Grembruch and Hansmann described transabdominal amniocentesis to improve ultrasound imaging (13). Quétel et al. used amniocentesis in patients with oligohydramnios and were able to provide an adequate acoustic window and perform a comprehensive ultrasound evaluation (10). They confirmed the diagnosis of ruptured membranes by transabdominal instillation of indigo carmine and observed the passage of blue dye into the vagina. Fluid could be aspirated during the amniocentesis procedure for evaluation and the cells cultured for karyotyping.

Antepartum Indications: Therapeutic

Fisk and colleagues (8) performed serial amniocentesis in a few selected cases and found that they could avert lung hypoplasia. Serial infusions were initiated as soon as feasible after the diagnosis of oligohydramnios was made and terminated after the canalicular phase of lung development was complete. In the setting of PROM, some investigators demonstrated that successful amniocentesis resulted in prolonged gestation, improved neonatal outcome, reduced incidence for pulmonary hypoplasia, and fewer abnormal neurologic sequelae compared with those patients with persistent oligohydramnios (14,15). However, the Cochrane Collaboration review concluded that there was too little evidence to show the beneficial effects of amniocentesis to the fetus following PROM (16). Since pulmonary hypoplasia remains the most common cause of neonatal death following vesico-amniotic shunting for obstructive uropathy, serial amniocentesis may improve the neonatal outcomes for this condition.

Antepartum amniocentesis has been proposed to improve the success rate of external cephalic version. Benifla et al. instilled about 800 mL of solution transabdominally into the amniotic cavity of the patients who had failed standard attempts at external version. In each case, ($n = 6$), a successful external version resulted after the amniocentesis (17). However, others found that transabdominal amniocentesis of 1000 mL of solution into the amniotic cavity did not improve the successful external version ($n = 7$) (18). The Cochrane Collaboration review concluded that there was too little evidence to show the benefit of transabdominal amniocentesis in external cephalic version (19).

Intrapartum Indications: Diagnostic

An indwelling, intrauterine, fluid-filled pressure catheter was initially introduced to monitor uterine tone and uterine activity. The diagnostic use of this medical device has been expanded. In the clinical setting of chorioamnionitis, fluid may be aspirated from a catheter port for Gram-stain evaluation

with or without culture and sensitivity, as clinically indicated. A paucity of amniotic fluid may be detected at the time of amniotomy. This could signify thick meconium or oligohydramnios.

Intrapartum Indications: Therapeutic

Using pregnant monkeys, Gabbe and coworkers demonstrated that removal of amniotic fluid produced variable decelerations, which were subsequently eliminated when the fluid volume was restored (20). Many have reported that a similar mechanism of using fluid as an umbilical cord cushion, via transcervical amniocentesis in the setting of oligohydramnios, results in a significant improvement in variable and prolonged decelerations, which do not otherwise respond to conventional methods (intravenous fluids, repositioning, O₂ administration, and manipulation of the presenting fetal part).

Accurate measurement of the amount of fluid retained is difficult, because unknown quantities of fluid may leak out during transcervical therapy. Serial ultrasound evaluation of the AFI may be useful in assessing the change as a guide for further infusion therapy including avoiding polyhydramnios (2,3,10,21). It is important to define the end point of the amniocentesis such as AFI of 8 cm, total volume of solution infused, total rate infused, or the resting tone of the uterus.

Intrapartum Indication: Prophylactic

Oligohydramnios in the setting of structurally normal fetuses occurring in the intrapartum period may be caused by membrane rupture, FGR, or postdates. With the loss of the amniotic fluid cushion, there is an increased risk of cord compression, which may lead to variable or prolonged decelerations. These decelerations may be associated with hypoxia and acidosis. Using amniocentesis, variable decelerations have been eliminated or reduced in frequency or severity during the first and second stages of labor, thereby reducing the associated hypoxia and acidosis and leading to an improved fetal acid–base status at delivery (2,4,5,20).

With prophylactic restoration of amniotic fluid volume at term, Strong and colleagues (3,21) reported a decreased incidence of meconium aspiration syndrome, severe variable decelerations, end-stage bradycardia, operative delivery for fetal distress, and low umbilical artery pH values. Other investigators (21–24) concluded that amniocentesis prophylaxis at 36 weeks or greater in patients with membrane rupture and oligohydramnios (AFI <5 cm) resulted in reduced intrapartum morbidity, decreased rates of cesarean delivery, and decreased episodes of fetal intolerance to labor. They also concluded that there were improved umbilical cord gas values, neonatal outcomes, and improved Apgar scores.

The presence of meconium may be the natural response of the gastrointestinal system to maturation. It may also be the response of the fetus to a stressful condition such as hypoxia, acidosis, or vagal stimulation. Generally, these etiologies are distinguished by the normality of the fetal heart rate pattern, with completely normal patterns being indicative of normal maturation.

Meconium has been associated with increased perinatal morbidity and mortality, especially due to aspiration of meconium-stained amniotic fluid. Meconium aspiration syndrome, defined as respiratory distress requiring mechanical

ventilation in a neonate with meconium aspiration, carries a mortality rate of approximately 25% and accounts for about 2% of all perinatal deaths. The passage of meconium in utero occurs in 8% to 16% of all deliveries; however, meconium aspiration syndrome occurs in only 1% to 3% of all cases of meconium-stained fluid (25). Meconium aspiration may occur before or during labor, or during the process of delivery. When meconium is aspirated into the lower respiratory tract, mechanical obstruction and chemical inflammation may occur.

Prior to the use of amnioinfusion, combined obstetric and pediatric suctioning of the neonate's airway during and after delivery was the mainstay of preventing meconium aspiration syndrome. This technique, as described by Carson and colleagues (26), was reported to decrease the frequency of meconium aspiration syndrome, assuming the aspiration occurred during the delivery process.

Some investigators reported amnioinfusion's beneficial effects in laboring patients who had meconium and oligohydramnios. Amnioinfusion resulted in a decreased incidence of:

1. 1- and 5-minute Apgar scores <7;
2. meconium visualized below the cords and in the oropharynx;
3. the presence of thick meconium in selected clinical settings;
4. umbilical arterial cord pH values <7.20;
5. intrapartum fetal distress;
6. operative delivery for fetal distress;
7. cesarean delivery rates; and
8. need for positive pressure ventilation of the newborn (27–29).

It was noted that the rates of cesarean delivery for arrest disorders were similar in the amnioinfusion and the control groups.

The Cochrane Collaboration recent review concluded that amnioinfusion during labor for meconium-stained amniotic fluid showed (i) no improvement in the perinatal outcomes if the labor and delivery unit has adequate monitoring of fetal condition and (ii) a significant improvement in the perinatal outcomes if the labor and delivery unit has limited capacity in monitoring fetal conditions during labor (27).

In summary, amnioinfusion provides an additional therapeutic option in labor to treat patients experiencing variable and prolonged decelerations that are unresponsive to conventional methods. Amnioinfusion also allows for prevention of fetal heart rate–related complications when used prophylactically in the intrapartum setting of oligohydramnios (30).

CONTRAINDICATIONS

In general, absolute contraindications to vaginal delivery are also absolute contraindications to intrapartum transcervical amnioinfusion. These include placenta previa and prior ruptured uterus. Other contraindications include conditions in which there would be no fetal benefit, such as lethal fetal anomalies and fetal death. The relative contraindications are listed in Table 1.

Clear evidence of impending fetal hypoxia or acidosis generally requires expedient delivery rather than temporization with amnioinfusion. Maternal exclusions include maternal

Table 1 Relative Contraindications to Amnioinfusion

Uterine anomalies
Chorioamnionitis
Maternal heart disease class II, III, IV
Fetal growth restriction
Fetal malformations
Malpresentation
Classical or unknown cesarean section scar
Abruptio placentae
Multi-fetal gestation

heart disease (New York Heart Association functional classification II or greater), as noted by Sadovsky and colleagues due to potential fluid overload from absorption (29). Abnormal uterus such as septate uterus may be less distensible and less pliable to amnioinfusion, thus less timely change in the pressure–volume curve. Whether chorioamnionitis is a contraindication is controversial, since some consider this condition to be an indication.

PROTOCOLS

A variety of protocols for amnioinfusion have emerged, all of which have common elements and guidelines. The common elements can be divided into pre-infusion preparation and evaluation, infusion equipment and monitoring, and post-infusion evaluation. The common guidelines are patient education and nursing in-service, evaluation of equipment, defining eligibility for infusion, and delineating the limits of the infusion. The ideal protocol defining the recommended infusion technique and rate has not been established. Various protocols are available, with variations defined by different authors for their own purposes. No controlled study has demonstrated the superiority of any given protocol.

In general, an eligible patient, during labor, has one or more of the following indications:

1. Variable deceleration with or without oligohydramnios;
2. Meconium amniotic fluid at term with limited monitoring capability;
3. Oligohydramnios either at term or preterm as a result of ROM; and/or
4. Oligohydramnios with intact membranes.

Variable decelerations, as previously discussed, are attributed to cord compression, with multiple studies showing that relieving the cord compression and improving the oxygen delivery to the fetus improve the intrauterine environment and the neonatal outcome.

The recommended protocol may include the following:

1. Informed consent concerning the clinical setting, risks and benefits, and alternatives. Oral consent may be legally sufficient, but it is best followed by written consent for amnioinfusion and cesarean delivery, if indicated.
2. A pelvic examination is performed to verify presentation, absence of cord prolapse, cervical dilatation and effacement, and fetal station.
3. Membrane rupture should be confirmed prior to transcervical amnioinfusion. An internal fetal heart

- rate electrode and an intrauterine pressure catheter, the latter ready for amnioinfusion, should be placed appropriately.
4. Some authors perform ultrasound for amniotic fluid volume index at the start as well as serially, but this may be unnecessary. Strong and coworkers (21) showed that 250mL of infusion into a relatively closed system increases the amniotic fluid volume index by 4 to 4.3cm (range 0–7.7cm).
 5. The intrauterine catheter system chosen should be able to monitor intrauterine pressure and instill amniotic fluid.
 6. The fluid chosen for infusion is either normal saline or lactated Ringer's.
 7. Consider warming the infusion to 37°C for the preterm fetus or rapid infusion.
 8. Infuse normal saline at a rate of 10 to 14mL/min. If a faster rate is carried out (e.g., 15–25mL/min by gravity), then warming the fluid to 37°C is recommended. The initial infusion volume is generally 500 to 600mL. Some recommend stopping the infusion after a bolus, while others recommend continuous infusion at a lower rate (2–3mL/min).
 9. End points for the infusion are individualized, based on experience and the purpose to be achieved. These include:
 - (a) a predetermined volume of 600 to 1000mL;
 - (b) resolution of variable decelerations;
 - (c) an AFI of 8 to 10cm; and
 - (d) a slow continuous irrigation and lavage at 2 to 3 mL/min, as long as fluid is continually draining out of the uterus.
 10. If sonographic monitoring is available, the following guidelines are recommended:
 - (a) If AFI >10cm, no additional bolus is recommended.
 - (b) If AFI is 5 to 10cm, a second bolus of 250mL is added and reassessment by sonogram is conducted.
 - (c) If AFI <5cm, a second bolus of 500mL is added and reassessment by sonogram is conducted.
 11. Periodic re-bolus with 500 to 600mL of fluid every 6 hours or a constant low infusion rate of 2 to 3mL/min may be used, depending on uterine tone and AFI.
 12. Periodic assessment of the fetal heart rate pattern, uterine tone and activity, volume infused, vaginal leaking, and progress of labor is necessary.
 13. Evaluation for complications.

Meconium-staining amniotic fluid presents potential meconium aspiration and the meconium aspiration syndrome. Amnioinfusion is effective in diluting meconium but may not reduce the incidence of the neonatal sequelae.

Preterm PROM presents two major concerns, namely, potential cord compression with its sequelae and intrauterine infection. There should be a low threshold to initiate therapeutic amnioinfusion and systemic chemoprophylaxis in the appropriate clinical setting.

Oligohydramnios at term, with membrane rupture occurring during labor, subjects the fetus to the potential of cord compression and its sequelae. The protocol recommended is the same as that for variable decelerations.

COMPLICATIONS

The adverse effects and potential complications of amnioinfusion are summarized in Table 2.

In a survey, 26% of centers reported at least one associated complication. The most frequent complication was uterine hypertonus (14%), followed by fetal heart rate abnormalities (9%) (30).

Although Posner and colleagues (31) found no change in uterine tone with controlled volumes of amnioinfusion and monitoring, they did report polyhydramnios with over-infusion. Two cases of polyhydramnios with uterine tenderness, one initially thought to be placental abruption (32) and the other with elevated uterine tone and fetal bradycardia from the amnioinfusion (33), were reported. In both cases, when the excess fluid was removed, the elevated uterine tone and uterine tenderness were relieved. In the case reported by Tabor and Maier, the bradycardia resolved after the excess fluid was removed (33). Over-distension and elevated uterine tone from amnioinfusion could disrupt a previous cesarean section scar. One case of a disrupted uterine scar was noted during a repeat cesarean delivery in which there was no resolution of the variable decelerations with amnioinfusion (1). Strong and colleagues (34) reported no change in the incidence of uterine scar disruption.

One case of cord prolapse was reported, but it was the same case in which the delivery was assisted by mid-forceps. No difference in the incidence of nuchal cords was demonstrated (31).

Miyazaki and Taylor (1) noted one case of fetal bradycardia, which occurred during rapid infusion of room temperature fluid (400mL over 8 minutes). The proposed mechanism was sudden chilling, leading to vasoconstriction, hypertension, and reflex bradycardia in the fetus. They noted no episodes of bradycardia when the infusate was warmed to 37°C, regardless of the infusion rate. Thus, warming of the fluid appears unnecessary if the infusion rates are limited to 10 to 15mL/min or less.

The rate of amnionitis as a result of amnioinfusion is variable (10,21). Patients with a higher rate of amnionitis also had more vaginal examinations. When this element was corrected, the rate was not significantly different from that of the control (non-infused) group (29). The majority of investigations reported no significant change in the rates of amnionitis associated with amnioinfusion.

Table 2 Complications of Amnioinfusion
Potential neonatal electrolyte imbalance
Potential neonatal hypothermia
Umbilical cord prolapse
Acute polyhydramnios
Fetal bradycardia
Elevated uterine tone
Previous cesarean section scar disruption
Amnionitis/endometritis
Amniotic fluid embolus

Nageotte and coworkers (4) noted that there were no significant differences in the basic electrolytes (Na, K, Cl, and CO₂) in newborns delivered following amnioinfusion as compared with those not subjected to amnioinfusion. The infusate used in this study was normal saline.

No conclusive evidence of the effect of amnioinfusion on the length of labor is available. The evidence presented by Strong and colleagues (3) suggested that there was a significant increase in the length of labor from 10.1 ± 6.5 to 16.8 ± 12.1 hours in their group, whereas Schrimmer and coworkers (5) reported a shorter duration of labor in their group of patients. Macri and colleagues (35) noted no significant change in the lengths of labor between the control group and the amnioinfusion group.

Dibble and Elliott (36) reported possible amniotic fluid embolus in two cases following amnioinfusion. No direct association was made to this rare pregnancy complication and amnioinfusion. They proposed that these two cases were mild because of the dilutional effect of the infusate on the particulate matter in the amniotic fluid. Other authors have also reported maternal respiratory distress in association with amnioinfusion (37,38).

CONCLUSIONS

Amnioinfusion is useful during the intrapartum period for relief of variable and prolonged decelerations, and obtaining fluid for evaluation of meconium staining and microbiology.

Amnioinfusion in the antepartum period may be useful in improving the ultrasound image, obtaining fluid for karyotype or culture and restoring fluid volume to decrease the likelihood of lung hypoplasia, arthrogryposis, or other fetal compression disorders in the setting of oligohydramnios.

Amnioinfusion has been an established part of the clinical management of complicated obstetric patients.

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