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Intrapartum Fetal Resuscitation: A Review

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Abstract

Fetal distress in labor results in progressive hypoxia and acidosis. The goal of fetal intrapartum resuscitation (FIR) is to optimize the fetal condition in utero so that labor may continue safely, or to improve fetal wellbeing prior to emergency delivery. The specific measures employed aim to increase oxygen delivery to the placenta and fetus in order to reverse hypoxia and acidosis. Intrauterine resuscitation encompasses maternal repositioning, reducing uterine activity, oxygen administration, amnioinfusion, optimizing maternal fluid status and correction of hypotension, and modifying maternal expulsive efforts. It helps to "buy time" to optimize the fetal condition while preparing for an impending delivery, or an emergency cesarean section. Evidence for this review was acquired by searching Pubmed, MEDLINE, EMBASE, SCOPUS, and Cumulative Index to Nursing and Allied Health. A hand search from 1950 to 2007 was not limited to English-language articles. Retrieved articles were examined for bibliographies, and cross-referencing was done.

INTRODUCTION

The goal of fetal intrapartum resuscitation (FIR) is to optimize the fetal condition in utero so that labor may continue safely, or to improve fetal wellbeing prior to emergency delivery. The term “fetal distress” is imprecise, non-specific, and has little positive predictive value ([1]). Parer and Livingston ([2]), defined fetal distress a “progressive fetal asphyxia that, if not corrected or circumvented, will result in decompensation of the physiologic responses (primarily redistribution of blood flow to preserve oxygenation of vital organs), and cause permanent central nervous system damage, and other damage or death”. The rationale for the introduction of fetal heart rate (FHR) monitoring was that it could serve as a screening test for the recognition of asphyxia at a sufficiently early stage so that timely obstetric intervention would avoid asphyxia-induced brain damage or death ([3]).

Fetal distress accounts for up to 40% of instrumental deliveries, and 30% of caesarean sections ([4,5]). In the majority of cases, the fetus tolerates the normal stresses of labor, and the goal of delivering a healthy baby is achieved. The primary method of fetal assessment during labor is continuous electronic fetal monitoring (EFM), although in some cases, intermittent EFM or intermittent auscultation is used ([6]). Electronic fetal monitoring is an indirect measure of fetal oxygenation whose sensitivity is high, while specificity is low ([7,8,9]). These limitations present challenges to health care providers as they monitor the fetal status during labor, and implement resuscitative measures to promote fetal well-being based on EFM data. When non-reassuring fetal status is diagnosed using conventional FHR monitoring methods, once uterine hyperstimulation and maternal hypotension are excluded, the prevailing treatment for this complication is an emergency delivery, usually performed via cesarean section.

PATHOPHYSIOLOGY OF INTRAUTERINE ASPHYXIA

The dependence of the fetus on the mother for exchange of oxygen and carbon dioxide is reliant on adequate maternal blood gas concentrations, uterine blood supply, placental transfer and fetal gas transport. Disruption of any of these can cause fetal hypoxia, which, despite compensatory mechanisms, may lead to acidosis, which if uncorrected, is associated with significant neonatal morbidity and mortality, and long term sequelae. ([10]).

Uterine contractions produce a transient decrease in blood flow to the placenta and the fetus, which may lead to the disruption of gas exchange across the placental barrier. Despite fetal adaptive mechanisms, if repetitive or prolonged reduction of blood flow occurs, it may lead to fetal acidemia. The degree to which fetal adaptive responses to hypoxia are effective in preventing asphyxia depends on the underlying health of the fetus and the placenta, as well as the duration, frequency, and intensity of the hypoxemic insults. There are several adaptive mechanisms that facilitate transfer of gases between mother and fetus (Table 1).

Figure 1

Table 1: Fetal adaptive responses to hypoxia

- Decrease in heart rate
- Reduction in oxygen consumption secondary to cessation of nonessential functions such as gross body movements
- Redistribution of cardiac output to preferentially perfuse vital organs; and
- Switch to anaerobic cellular metabolism

The partial pressure of oxygen in the mother's circulation is higher than that in fetal circulation, which facilitates maternal-to-fetal transfer of oxygen across the placental interface. Fetal adaptive mechanisms support functioning and growth in a low-oxygen environment; fetal blood has a higher hemoglobin level than adult blood, and fetal hemoglobin has a higher affinity for oxygen than maternal hemoglobin at the same partial pressures of oxygen. In addition, fetal circulation “overperfuses” certain organs such as the brain (11). Several studies have looked at the neurological outcome of neonates who were severely asphyxiated at delivery (10,12,13,14,15,16,17). Although the cutoff of pH used to define severe acidosis and the age at follow up varied, conclusions from the studies indicated that although mortality may be slightly increased, the predictive value of acidosis at birth for neurological sequelae was found to be poor. Patterns predictive of current or impending fetal asphyxia were set out by the National Institute of Child and Human Development (NICHD) Research Planning Workshop (3). These patterns included recurrent late or variable decelerations or substantial bradycardia, and absent FHR variability.

DIAGNOSIS OF ACIDOSIS

Fetal heart rate monitoring during labour can give us an indication of fetal hypoxia and acidosis. When the FHR tracing is reassuring, there is a predictive value of 99% for confirming a non-acidotic fetus; an abnormal FHR tracing has a positive predictive value of 50% for fetal compromise (18). Measurements of intrapartum acid-base status obtained from fetal scalp blood help decrease operative deliveries following false positive fetal heart rate traces (19). Several methods of continuous blood gas monitoring using an electrode attached to the fetus sub- or transcutaneously have been tried for pO2, pCO2, and pH (20,21). Although fetal scalp sampling has a greater specificity for fetal compromise than FHR monitoring alone, it is rarely practiced in many institutions because of its invasive nature, unreliable results, and procedure requirements (eg, station, dilation, ruptured membranes) (22). Fetal scalp or acoustic stimulation has also been used, and is predictive of the absence of fetal acidosis if positive, but is often negative, despite a healthy fetus (23). Therefore, for most clinicians, FHR monitoring represents the best available indirect measurement of fetal oxygenation in utero during labor (24). Fetal pulse oximetry (FPO) was proposed as an adjunctive means of fetal assessment, in the hope of increasing specificity. Several earlier studies (24,25,26) showed promise for the reduction in cesarean deliveries for the indication of a nonreassuring fetal heart rate using FPO. Bloom et al (27), reported on their multicenter randomized trial to evaluate the effectiveness and safety of FPO as an adjunct to conventional EFM to reduce the overall rate of cesarean deliveries for the indications of nonreassuring fetal heart rate and dystocia, and evaluated the potential side effects of such monitoring in both the mother and the neonate. They found that the fetal oxygen saturation was not associated with a reduction in the rate of cesarean delivery or with improvement in the condition of the newborn, thus discounting this diagnostic tool as a means of fetal surveillance.

INTRAPARTUM FETAL RESUSCITATION

MATERNAL OXYGENATION

Maternal oxygen administration has been used in an attempt to reduce fetal distress by increasing the available oxygen from the mother. Even though healthy women in labor have high blood oxygen saturation (SpO_2), it has been suggested that increasing inspired O_2 increases blood O_2 tension and results in more O_2 delivered to the fetus (28). Studies have shown that there was a more rapid increase in fetal oxygen saturation ($FSpO_2$) when O_2 was given, compared with the decrease in $FSpO_2$ when it was discontinued, suggesting that the fetus responds to the new placental O_2 gradient by accepting O_2 more rapidly than it gives it up (28). Fetal hemoglobin has a higher affinity for O_2 than adult hemoglobin, and fetal hematocrit is higher than adults. These physiologic factors allow for a steeper increase in fetal oxygen concentration and $FSpO_2$ during maternal O_2 therapy. Further, fetuses with low $FSpO_2$ may benefit more from O_2 therapy than fetuses with normal $FSpO_2$ (29).

Although results suggested that short-term (15 minutes) O_2 therapy may be beneficial for the fetus during labor, the results cannot be extrapolated to suggest that long-term O2 therapy during labor is of similar benefit (30,31,32). On the effects of long-term O_2 therapy during labor, Thorp and colleagues in a randomized trial found that more than 10 minutes of O_2 administration during the second stage of labor resulted in lower umbilical artery cord blood gas values compared with less than 10 minutes of O_2 administration, and no O_2 administration (33). In their report on the efficacy of 3 common intrauterine resuscitation techniques used during labor, Simpson and James prospectively evaluated intrauterine resuscitation techniques in healthy women during labor (29). Women were randomized to either a 500mL or 1,000mL intravenous (IV) fluid bolus over 20 minutes. Women were further randomized to 1 of 6 position sequences including supine, with the head elevated 30°, and left lateral and right lateral for 15 minutes each in succession. Differences in $FSpO_2$ were evaluated before, during, and after each intervention. Their results showed that an IV fluid bolus of 1,000 mL had a greater effect on $FSpO_2$ than an IV fluid bolus of 500 mL, further, fetal oxygen saturation was higher in a lateral position than in a supine position. Oxygen administration increased $FSpO_2$, and the effect persisted for more than 30 minutes after the O_2 was discontinued. For fetuses with $FSpO_2$ less than 40% before maternal O_2 administration, the increase was greater than for those with $FSpO_2$ of 40% or greater. They concluded that O_2 administration at 10 L/min via non-rebreather face mask was effective in increasing $FSpO_2$ during labor.

It seems evident that when administering oxygen to the mother, that it is important to use the method that provides the highest fraction of inspired oxygen (FiO_2) to achieve maximum benefit. A non-rebreather facemask works best because the FiO_2 at 10 L per minute is approximately 80% to 100%, as compared to a simple face mask (FiO_2 27%–40%) or nasal cannula (FiO_2 31%) (29). Other studies have not found any fetal benefit from maternal oxygen administration (34,35,36). However, it may have a role during acute fetal distress, based on its effect over the short term at caesarean section (37).

IMPROVING BLOOD SUPPLY TO THE UTERUS

Maternal body position can influence fetal well-being without uterine contractions; results of non-stress tests (NSTs) are most unfavorable when mothers lie on their back (38,39,40,41). 'Aortocaval compression' describes compression of the inferior vena cava and the aorta by the gravid uterus in women at term (42,43,44). Acute fetal distress can be caused by either hypoperfusion of the uteroplacental unit secondary to maternal hypotension, or occult aortic compression causing a reduction in iliac arterial flow. The compression of the aorta by the pregnant uterus decreases the blood pressure and, especially, pulse pressure distal to the affected level (supine hypotensive syndrome) (45). Further, in the supine position, the lung function is also worsened in late pregnancy, causing a lower oxygen tension of the blood (46,47,48). Due to the dextrorotation of the gravid uterus and its anatomical relation to the inferior vena cava some believe that a left lateral tilt is better for the fetus, however, other studies (29,49) have shown no significant differences in fetal status between left and right positions. Maternal cardiovascular compromise and fetal stress in maternal supine position, and their relief in the full lateral position, are well recognized (50,51,52). Inferior vena cava compression is demonstrable up to 12.5°–15° of lateral tilt, and aortic compression up to 30°. The use of 15° of tilt at cesarean section, and 30° during labour, reduces the effects considerably. This amount of tilt, if applied correctly, reduces inferior vena cava compression (53).

INTRAVENOUS FLUIDS

Animal studies have shown that boluses of intravenous crystalloids increased maternal arterial blood pressure and placental site blood flow, and decreased vascular resistance, however, there was no rise in fetal pO2 (54). In hypovolemic or hypotensive women, blood volume shifts away from the uterus affecting oxygen delivery to the fetus. A bolus of 500ml of lactated Ringer's solution over 20 minutes significantly increases fetal oxygen saturation. The positive effects on fetal oxygen status continues for more than 30 minutes after the fluid bolus (29). An added benefit of boluses of intravenous crystalloids is its tocolytic effect on the uterus, however, the uterine activity returns to baseline after 20 minutes (55). It has been postulated that the tocolytic effects are related to naturetic peptide release from distension of the atrium (37). Beneficial effects of intravenous fluids might be due to an increase in cardiac output (56), a reduction in uterine contractions (55), or a decrease in blood viscosity (54). However, caution should be exercised when increasing IV fluids or giving repeated IV fluid boluses in certain clinical situations such as preeclampsia, preterm labor treated with magnesium sulfate, the use of corticosteroids, and beta-sympathomimetic drugs, all of which confer an increased risk for pulmonary edema. Oxytocin has an antidiuretic effect; thus prolonged use of large dosage oxytocin can also lead to fluid overload if too much IV fluid is administered, particularly if the fluid is not isotonic.

IMPROVING PLACENTAL PERFUSION

Uterine contractions cause a cessation of maternal intervillous placental blood flow resulting in relative fetal hypoxia with recovery taking 60-90 seconds (57). If this intermittent interruption of blood flow becomes too frequent the fetus is at risk for hypoxemia and acidosis. It stands to reason that reducing both the frequency and intensity of uterine contractions will improve placental perfusion. This can be affected by either reducing or discontinuing oxytocin infusion, or administering tocolytics. Oxytocin can cause hyperstimulation resulting in fetal distress (58); a simple means of reversing its effects is to stop the infusion. However, the effects of the discontinued oxytocin may still be evident. After 15 minutes of cessation, there is a 22% reduction in activity, by 30 minutes, a 39% reduction, and by 45 minutes a 48% reduction (59). To achieve a more rapid reduction in oxytocin action, tocolytics may be used (60,61). The commonly used ?-agonist tocolytic is terbutaline 250?g given either subcutaneously or intravenously (61). Glyceryl trinitrate (GTN), with a half-life of 3 minutes is likely to have a faster onset of action and elimination than other tocolytic agents (62). Its use as a sublingual spray has also been described for acute uterine relaxation (63).

Briozzo et al (64), conducted a prospective randomized study to determine whether FIR using tocolysis and delayed delivery was better for the fetus than emergency delivery when fetal hypoxia was suspected because of a non-reassuring FHR pattern using conventional heart rate monitoring. They concluded that tocolysis and delayed delivery rendered better immediate neonatal results than emergency delivery when fetal distress was suspected because of a non-reassuring fetal heart pattern. In addition, it may decrease the need for emergency delivery without increasing maternal and fetal adverse side-effects.

Hyperstimulation may also follow the use of prostaglandins and their analogues when used for pre-induction cervical ripening or induction of labor. When this occurs, the remaining medication should be manually removed, the vagina irrigated, and if needs be tocolytics given (37).

IMPROVING FUNIC BLOOD FLOW

Amnioinfusion prevents or relieves umbilical cord compression usually caused by oligohydramnios. Amnioinfusion has been shown to reduce the incidence of variable fetal heart decelerations, but not late decelerations or reduced variability (65,66,67). In a randomized prospective study by Mino et al (66), 200 term pregnancies with low amniotic fluid due to vaginal loss were randomly chosen to receive intrapartum amnioinfusion or standard obstetric care without amnioinfusion. Fetal heart rate pattern, method of delivery and neonatal acid–base status were compared. They found that amnioinfusion improved fetal heart rate pattern, lowered the incidence of operative delivery, and improved neonatal acid–base status. In another prospective randomized study, Miyazaki and Nevarez (67), investigated the effect of intrauterine saline amnioinfusion for the relief of repetitive variable decelerations in the first stage of labor. Their study showed that saline amnioinfusion was a simple, safe, and effective therapy for the relief of repetitive variable decelerations in the first stage of labor and could lower the incidence of cesarean sections for fetal distress in nulliparous patients.

The procedure of amnioinfusion uses the following equipment: a double lumen intrauterine pressure catheter, normal saline solution at room temperature, a fetal monitor and intravenous tubing. Continuous close monitoring using a fetal scalp electrode is recommended. After obtaining informed consent, a vaginal examination is performed to evaluate for cord prolapse, establish dilatation and confirm presentation. The fetal scalp electrode is placed, followed by an intrauterine pressure catheter to document resting tone (< 15 mm Hg). Normal saline is linked to the intravenous tubing, and primed as it would be for intravenous use, and is then inserted into the infusion port on the three-way stop cock of the intrauterine pressure catheter. Recommendations for infusion protocols may vary by institution. A common protocol (68), starts with an initial bolus of 250 mL infused over 20 to 30 minutes. The rate is then adjusted according to the severity of decelerations, but usually at a rate of 10 to 20 mL per minute up to 600 mL, or to resolution of the variable decelerations. An additional 250 mL beyond the volume at which decelerations resolve is administered, then the infusion is terminated, unless the decelerations resume. The infusion is a failure if 800 to 1,000 mL of saline does not result in termination of decelerations. The fetal heart rate and resting tone are assessed continuously during the intervention. If the uterine tone is persistently elevated, the infusion is discontinued, and the uterine pressure allowed to equilibrate. The resting uterine tone is reassessed, and the infusion discontinued if the new resting tone is 15 mm Hg above the baseline resting tone or 30 mm Hg maximum (68).An alternative protocol (69), is a bolus infusion of 250 to 1,000 mL of fluid at a rate of 10 to 15 mL/minute, followed by a continuous infusion of 100 to 200 mL/hour via pump infusion or gravity. Strong and associates (70), recommended saline infusion at 10 to 20 mL per minute through a blood warmer to prevent cold-induced fetal vasospasms; they continued the infusion until an amniotic fluid index of 8 cm was obtained. Owen and co-workers (71), recommended the infusion of 600 mL of normal saline at 10 mL per minute, followed by a continuous infusion at 3 mL per minute.

CORD PROLAPSE

Prolapse of the umbilical cord is a rare obstetric emergency that in the viable fetus warrants an expeditious delivery. Traditionally, this has been managed by minimizing pressure on the cord while preparing for delivery. The steps involve manual elevation of the presenting part, a knee-chest or Trendelenberg position, instillation of fluid in the bladder and funic reduction (72). Unless the cervix is fully dilated and a spontaneous or instrumental delivery can be achieved, most obstetricians would opt for delivery by cesarean section (37).

DELIVERY

While most fetuses tolerate transient hypoxic states, others with less reserve do poorly. Recurrent variable or prolonged decelerations during the second stage are associated with respiratory academia at birth (73,74). The use of sustained Valsalva bearing down efforts results in adverse fetal acidemia or deoxygenation. Specifically, sustained bearing down efforts result in lower maternal blood pressure and placental blood flow, lower fetal pH and PO_2, higher PCO_2, more frequent occurrence of nonreassuring fetal heart rate patterns, delayed recovery of FHR decelerations and subsequent newborn acidemia, and lower Apgar scores (75,76,77). Clinical trials indicate that the use of “non-coached” pushing prevents fetal hypoxic effects and without the risk of adverse maternal, fetal, or neonatal outcomes (78,79). If the fetal heart pattern is nonreassuring during second stage pushing efforts, the best approach is to stop pushing temporarily and allow the fetus to recover (49). One of the ways to reduce the stresses to the fetus during the second stage of labor is to shorten the active, sustained, coached closed-glottis pushing (79,80). Time spent in the phase of active bearing down is the more critical time interval than the total duration of the second stage with regards to the decline in fetal pH and the development of hypoxia and acidosis (81). In women with epidural anesthesia, if there are no maternal or fetal conditions that require rapid birth, it is best to wait until the mother feels the urge to bear down rather than encourage her to push prematurely. In the PEOPLE (Pushing Early or Pushing Late with Epidural) (82) multicenter, randomized, controlled trial undertaken to determine whether a policy of delayed pushing for nulliparous women with continuous-infusion epidural analgesia reduced the risk of difficult delivery. A policy of delayed pushing resulted in a reduction in the risk of difficult delivery and an increase in the likelihood of abnormal umbilical cord pH. They concluded that delayed pushing was an effective strategy to reduce difficult deliveries in nulliparous women.

ANESTHESIA

There is a paucity of studies on the quickest and safest anesthesia for an emergency cesarean section for fetal distress. The National Sentinel Audit of Cesarean sections defined 30 minutes as a standard for decision-to-delivery interval for an emergency delivery (52,83). In a systematic review on the effects of epidural analgesia on labor, maternal, and neonatal outcomes, Leighton et al., reported that analgesic method did not affect fetal oxygenation, neonatal pH, or 5-minute Apgar scores; however neonates whose mothers received parenteral opioids required naloxone and had low 1-minute Apgar scores more often than did neonates whose mothers received epidurals (84). In their meta-analysis to review the effects of epidural versus parenteral opioid analgesia, Halpern et al, reported that patient satisfaction and neonatal outcome were better after epidural than parenteral opioid analgesia (85).

The need for general anesthesia for cesarean section for “fetal distress” is controversial, with evidence supporting the use of regional anesthesia in these cases (86). If a functioning labor epidural is in-situ, it can be used in all but the most extreme cases by administration of a rapid onset local anesthetic such as 3% 2-chloroprocaine or 2% lidocaine with epinephrine. The risks and benefits of general anesthesia to the neonate have been well documented in several studies(86) A comparison of general and epidural anesthesia found that the general anesthesia group had lower pH values (87). Ong and colleagues (88) found that general anesthesia was associated with a higher incidence of low Apgar scores as compared to regional anesthesia. Gale and colleagues (89) reported that the number of neonates needing “respiratory assistance” at birth was twice as high in the group whose mothers received general as compared to epidural anesthesia, and Marx and colleagues (90) reported that despite the presence of fetal distress, 1 min Apgar scores were significantly better in the group receiving spinal as compared to general anesthesia. In a small prospective, randomized study by Dyer et al (91), on neonatal outcomes after spinal versus general anesthesia for cesarean delivery in preeclamptic patients with a nonreassuring fetal heart trace, spinal anesthesia for cesarean delivery was associated with a greater mean neonatal umbilical arterial base deficit and a lower median umbilical arterial pH than general anesthesia.

A meta-analysis of anesthesia for cesarean section and neonatal acid-base status included elective and emergency cesarean sections (92). The conclusion was that spinal anesthesia could not be considered safer than epidural or general anesthesia for the fetus. Although differences were moderate, the reduced pH could further impact upon the outcome for an already compromised fetus. They caution that there were many good reasons to use spinal anesthesia for cesarean section, but fetal ? neonatal welfare was not amongst them. In a review of anesthesia and analgesia on the risk of fetal distress during labor and cesarean section, Bonnet et al., concluded that all obstetric anesthesia and analgesia techniques are associated with a theoretical risk of fetal distress, but given the fact that regional anesthesia techniques are also associated with well-demonstrated benefits for the mother and the newborn, the latter remains the preferred choice in obstetric practice (93).

While the quality and choice of anesthesia for cesarean section has significantly improved over the last two decades, general anesthesia usage has decreased to the point where, in some centers, it is an occasionally used technique for severe fetal distress. The increase in anesthetic choices has led to inconsistencies in practice between individual anesthetists, and between regions and nations (94). Spinal anesthesia is now the commonest technique used in the UK for elective cesarean section (95), and its rapid onset has also established it as an alternative to general anesthesia in emergency cases (94).

The choice of anesthesia used in a situation is influenced by a variety of factors such as the urgency of the procedure, maternal status, and physician and patient preference. If the cesarean section must be performed urgently because of a nonreassuring FHR pattern, an anesthetic technique that can be performed relatively quickly is preferred since anesthesia must be achieved expeditiously. Most practitioners agree that inducing general anesthesia is the most reliable means of quickly achieving operative anesthesia for cesarean. However, highly skilled individuals may be able to rapidly induce spinal anesthesia. In fact spinal anesthesia is increasingly being used as a substitute for general anesthesia in all but the most emergent situations (96). In summary, not every abnormal fetal heart rate pattern should be diagnosed as "fetal distress" and many of these cases can be safely performed under neuraxial block. The American College of Obstetricians and Gynecologists has supported the use of regional anesthesia in these cases (1).

CONCLUSION

Intrapartum fetal resuscitation techniques may improve the fetal condition in select cases (Table 2).

Figure 2

Table 2: Recommendations for intrapartum resusucitation

1. Monitoring	• Electronic fetal heart rate monitoring - NICHD guidelines (3) • Fetal scalp pH • Fetal scalp lactate • Fetal pulse oximetry (?)
2. Improving maternal oxygenation	• O_2 administration at 10 L/min via non-rebreather face mask
3. Improving blood supply to the uterus	• Maternal left lateral tilt of ≥15∘ • Bolus of 500ml of lactated Ringer's solution over 20 minutes
4. Improving placental perfusion	• Use of appropriate oxytocin regimen • Discontinue oxytocin in presence of fetal distress/hyperstimulation • Use of tocolytics in presence of fetal distress/hyperstimulation
5. Improving funic blood flow	• Amnioinfusion • Change of maternal position
6. Delivery	• Discourage premature, coached closed-glottis, pushing • Use of regional anesthesia for cesarean section

It helps to "buy time" to optimize the fetal condition while preparing for an impending delivery, or an emergency cesarean section, or as an interim strategy while awaiting cesarean section or assisted delivery. The potential reversibility of factors that have caused an episode of fetal distress will determine which aspects of intrauterine resuscitation will be appropriate in an individual patient (97). Evidence of ongoing fetal distress, such as late decelerations or bradycardia, despite the various resuscitation methods described would mandate emergency delivery. The nature of abnormal fetal heart rate tracing would dictate how long one might delay delivery or give the interventions a chance to work before resorting to emergency delivery. Most of the methods described have not been subjected to rigorous randomized controlled trials in the acute situation of fetal distress, and is often considered standard care and common sense (6,49). It is not feasible to randomize women to a group in whom no active measures to reverse fetal distress is used. Single interventions may have less effect than a combination, and there might even be potentiation between manoeuvres, further, there is also a problem of defining the outcomes to be studied (86,98). However, with the various techniques described, it may be of help in improving the status of the fetus in utero. The limitations of some of the studies included lack of randomization, an arbitrary fetal scalp pH of 7.2 as cut-off for the diagnosis of distress, and inconsistent end-points, ie. umbilical artery pH at delivery, 1 and 5 minute Apgar scores, neonatal intensive care admission, and long-term neurological sequelae. Future research should focus on the use of standardized definitions of FHR patterns with respect to

1. Reliability of the technique of FHR pattern interpretation ie. a study of intraobserver and interobserver agreement in FHR interpretation.
2. Validity of the technique ie. an epidemiologic study of the frequency of the different FHR patterns correlated with characteristics of the mother and infant.
3. Causal relationship between FHR patterns and their relationship to immediate and long-term outcomes. If the reliability and validity of FHR monitoring can be established, the final aspect of effectiveness of FHR monitoring needs to be established, that is, whether FHR monitoring can be used in a system of management to prevent intrapartum asphyxial brain damage.

A good trial on fetal resuscitation would require randomization based on fetal distress diagnosed using the “gold standard” of fetal scalp blood pH < 7.2, testing the methods used for resuscitation, and accounting for the variables. Each of the mentioned intrapartum resuscitation techniques would then stand up to scrutiny. The primary and secondary end-points would be neonatal outcomes, and childhood development, respectively. However, the ethics of expectant versus resuscitation or emergency management may be questioned. A survey of professionals who provide intrapartum care identified a lack of knowledge of intrauterine resuscitation (99). Recommendations are that all staff in maternity care units should be aware of fetal and maternal resuscitation techniques, and should maintain their skills with regular updating (100).

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