Placenta 36 (2015) 594–598

Contents lists available at ScienceDirect

Placenta

journal homepage: www.elsevier.com/locate/placenta

Predicting intrapartum fetal compromise using the fetal cerebro-umbilical ratio

S. Sabdia [a, b], R.M. Greer [a], T. Prior [a], S. Kumar [a, b, c, *]

[a] Mater Research Institute/University of Queensland, Aubigny Place, Raymond Terrace, South Brisbane, QLD 4101, Australia
[b] Mater Mothers' Hospital, Raymond Terrace, South Brisbane, QLD 4101, Australia
[c] Imperial College London, UK

ARTICLE INFO

Article history:
Accepted 28 January 2015

Keywords:
Cerebro-placental ratio
Cerebro-umbilical ratio
C/U ratio
Fetal compromise
Normal growth
Growth restriction
Pregnancy

ABSTRACT

Introduction: The aim of this study was to explore the association between the cerebro-umbilical ratio measured at 35–37 weeks and intrapartum fetal compromise.
Methods: This retrospective cross sectional study was conducted at the Mater Mothers' Hospital in Brisbane, Australia. Maternal demographics and fetal Doppler indices at 35–37 weeks gestation for 1381 women were correlated with intrapartum and neonatal outcomes.
Results: Babies born by caesarean section or instrumental delivery for fetal compromise had the lowest median cerebro-umbilical ratio 1.60 (IQR 1.22–2.08) compared to all other delivery groups (vaginal delivery, emergency delivery for failure to progress, emergency caesarean section for other reasons or elective caesarean section). The percentage of infants with a cerebro-umbilical ratio <10th centile that required emergency delivery (caesarean section or instrumental delivery) for fetal compromise was 22%, whereas only 7.3% of infants with a cerebro-umbilical ratio between the 10th–90th centile and 9.6% of infants with a cerebro-umbilical ratio > 90th centile required delivery for the same indication ($p < 0.001$). A lower cerebro-umbilical ratio was associated with an increased risk of emergency delivery for fetal compromise, OR 2.03 (95% CI 1.41–2.92), $p < 0.0001$.
Discussion: This study suggests that a low fetal cerebro-umbilical ratio measured at 35–37 weeks is associated with a greater risk of intrapartum compromise. This is a relatively simple technique which could be used to risk stratify women in diverse healthcare settings.

1. Introduction

Intrapartum hypoxia can develop from gradual deterioration of placental function, or from acute events such as placental abruption or cord prolapse and compression. While acute events are generally unpredictable and unpreventable, antenatal detection of chronic placental insufficiency has the potential to influence obstetric management including mode and timing of delivery thereby potentially improving perinatal outcomes.

Identifying which fetus will develop intrapartum compromise (or fetal distress) can be difficult. Protective mechanisms in the fetus usually mitigate the development of intrapartum hypoxia during labor, when uterine contractions reduce blood supply to the placenta by almost 60% [1]. These mechanisms include an increased preload and cerebral redistribution of cardiac output [2]. Some babies are at a higher risk of intrapartum compromise due to complications such as fetal growth restriction [3], however, as many as 63% of cases of intra-partum hypoxia occur in pregnancies with no antenatal risk factors [4].

We have recently shown that the cerebro-umbilical (C/U) ratio (ratio of the pulsatility index (PI) of the umbilical artery (UA) to the middle cerebral artery (MCA)), measured within 72 h prior to delivery is predictive of intrapartum fetal compromise [5]. A low ratio (<10th centile) was a risk factor for fetal compromise; conversely, a high ratio (>90th centile) appeared to be protective with a negative predictive value of almost 100% [5]. In addition, umbilical venous flow is also reduced in fetuses that go on to develop intrapartum fetal compromise [6].

Whilst these results are encouraging, fetal assessment within 72 h of delivery is logistically challenging outside of a dedicated research setting. Given the practical issues in performing an ultrasound close to labor and delivery, we wanted to ascertain if a

* Corresponding author. Mater Research Institute/University of Queensland, Level 3, Aubigny Place, Raymond Terrace, South Brisbane, QLD 4101, Australia. Tel.: +61 7 31632564.
E-mail address: sailesh.kumar@mater.uq.edu.au (S. Kumar).

http://dx.doi.org/10.1016/j.placenta.2015.01.200
0143-4004/

similar relationship still held if the Doppler indices were measured some weeks remote from delivery. Therefore, the aim of this study was to assess if a low C/U ratio (<10th centile) measured at 35–37 weeks was predictive of emergency delivery for intrapartum fetal compromise.

2. Materials and methods

This was a retrospective cohort study of women delivering at the Mater Mothers' Hospital in Brisbane between June 1998 and November 2013 using previous prospectively collected data from the institution's perinatal database. The Mater Mothers' Hospital is the largest maternity hospital in Queensland and a major tertiary centre. The study protocol was assessed and approved by the hospital's Human Research Ethics Committee (Reference number HREC/14/MHS/37).

All women with a singleton fetus undergoing an ultrasound scan between 35 and 37 weeks gestation with a UA PI < 95th centile for the gestation and had no contraindications for a vaginal delivery were eligible for inclusion in this study. Gestational age was calculated from either the last menstrual period or by the earliest ultrasound examination or correlation with both. Exclusion criteria included multiple pregnancy, known genetic conditions or congenital malformations, non-cephalic presentation, ruptured membranes, absent/reversed end-diastolic flow in the UA, unknown UA PI or MCA PI or unknown mode of delivery. Indications for requesting a fetal growth and wellbeing scan at 35–37 weeks varied, although the commonest reasons were uncertainty of fetal size or presentation on clinical examination, previous pregnancy complications or maternal anxiety. Demographic data collected included parity, maternal age, body mass index (BMI) and ethnicity (Caucasian, Asian, Indigenous (Aboriginal or Torres Strait Islander (ATSI)) or other).

The estimated fetal weight (EFW) was calculated using Hadlock's formula [7]. For all Doppler parameters, recordings were taken in the absence of fetal breathing movements. An automated tracing method was used incorporating at least 3 waveforms, and repeated 3 times to obtain a mean pulsatility index. The angle of insonation of the vessel was always kept <30°. The MCA was first imaged using color Doppler with the waveform then recorded from the proximal third of the vessel, distal to its origin at the circle of Willis. Either the right or left MCA was used depending on the quality of the waveform obtained. The UA Doppler waveforms were recorded from a free loop of cord. The C/U ratio was calculated for each patient by dividing the MCA PI by the UA PI. The primary outcome measure for this study was the occurrence of intrapartum fetal compromise (as diagnosed by the obstetric team) requiring emergency delivery (either caesarean section or instrumental delivery). Secondary outcomes included Apgar scores at 1 and 5 min, arterial cord blood gases if performed (arterial pH and base excess), and admission to the neonatal intensive care unit.

Given the retrospective nature of this study and the difficulty in applying a rigorous definition to the diagnosis of "fetal compromise" we chose to adopt a pragmatic approach and used the primary indication for delivery/intervention as recorded in the maternity database. We considered this definition reasonable, as the diagnosis of fetal compromise would generally have been made on the basis of an abnormal fetal heart pattern, fetal scalp pH or fetal scalp lactate, fully accepting the limitations of this methodology in our analysis.

Infants were grouped into five categories of mode of delivery: emergency delivery (instrumental or caesarean section) for fetal compromise, spontaneous vaginal delivery, emergency delivery for failure to progress (instrumental or caesarean section), emergency caesarean section for other reasons or elective caesarean section.

The UA PI, MCA PI and C/U ratios (stratified by < 10th centile, ≥10th–90th centile and ≥90th centile), parity, maternal age, BMI, distribution of ethnicity, gestational age at delivery, birthweight, Apgar < 7 at 5 min, cord arterial pH < 7.2, base excess >8 mmol/L and admission to the neonatal unit were obtained from the maternity database. Data was assessed for normality using the Shapiro–Wilk test.

All continuous variables showed a skewed distribution, and therefore the Kruskall–Wallis test or Wilcoxon Rank Sum test were used for comparisons between groups. Proportions were compared using a Chi-square test or Fisher's exact test if the expected cell frequencies were <5. Summary statistics are reported as median (IQR) unless otherwise indicated. Predictors of the need for emergency delivery for fetal compromise compared to all other modes of delivery were evaluated using logistic regression. Data was analyzed using Microsoft Excel and Stata version 13 (www.stata.com). Statistical significance was set at $p = 0.05$. No adjustment was made for multiple comparisons [8].

3. Results

3.1. Demographics

Over the study period, a total of 1381 women fulfilled the entry criteria. The median maternal age was 30 (26–34) years and median body mass index (BMI) was 23 (20–27)kg/m^2. The median gestational age at ultrasound was 36 + 1 (35 + 5–36 + 4) weeks. The median gestational age at delivery was 38 (37–39) weeks and median birth weight was 2870 (2478–3310) g. Forty one point eight percent of the study cohort were primiparous women. The proportion of births that were either induced or augmented was 27.7% (382/1381). It was not possible to differentiate between the two categories as categorization in the database was not specific enough to allow us to do this.

3.2. Modes of delivery

The proportion of emergency deliveries (instrumental or caesarean section) for fetal compromise was 9.0% (124/1381), spontaneous vaginal delivery (SVD) was 49.3% (681/1381), emergency delivery (instrumental or caesarean section) for failure to progress was 9.9% (137/1381), emergency caesarean section for other reasons was 8.9% (123/1381) and elective caesarean was 22.9% (316/1381).

3.3. Neonatal characteristics

Overall, Apgar scores at 5 min were available for 1378 infants; of these infants, 1.5% (21/1378) had an Apgar score of <7 at 5 min. Limited data was available for other neonatal indices. On the information available, 26% (12/46) had a cord arterial pH < 7.2, 12% (3/25) had a base excess > −8 mmol/L and 55% (295/541) required admission to the neonatal unit. The only neonatal outcome that differed ($p < 0.001$) across delivery groups was admission to the nursery, in which the group of infants that required emergency delivery for fetal compromise had the highest proportion of admissions (43.5% (54/124)) (Table 1).

3.4. Umbilical artery pulsatility index

The overall median UA PI of the study cohort was 0.91 (0.79–1.04). Babies that required emergency delivery for fetal compromise (instrumental or caesarean) had the highest median UA PI (0.99, 0.80–1.14) while the two groups that had the lowest median UA PI were SVD (0.90, 0.79–1.02) and emergency delivery for failure to progress (0.90, 0.77–1.00).

The UA PI differed ($p = 0.01$) between delivery groups. Infants born by emergency delivery for fetal compromise had higher UA PIs (0.99, 0.80–1.14) than those born by SVD (0.90, 0.79–1.02, $p = 0.002$) and those born by emergency delivery for failure to progress (0.90, 0.77–1.00, $p = 0.004$).

Sixteen point eight percent of babies (22/131) with a UA PI > 90th centile (1.20) required emergency delivery for fetal compromise compared to only 8.4% (12/143) of infants with a UA PI < 10th centile (0.69) and only 8.1% (90/1107) of infants with a UA PI 10th–90th centile ($p = 0.004$). The likelihood of having an emergency delivery for fetal compromise increased as the UA PI increased, OR 4.02 (95% CI 1.7–9.32), $p = 0.001$. Conversely, a low UA PI was associated with a decreased risk, OR 0.25 (95% CI 0.11–0.58), $p = 0.001$. Receiver-operator curve (ROC) analysis for the prediction of emergency delivery for fetal compromise using the UA PI found an area under the curve (AUC) of 0.58.

3.5. Middle cerebral artery pulsatility index

The median MCA PI for the entire cohort was 1.64 (1.41–1.89). The median MCA PI was lowest (1.54, 1.29–1.74) in babies who required emergency delivery (either caesarean section or instrumental delivery) for fetal compromise and highest (1.66, 1.45–1.91) in those that were delivered by SVD. The MCA PI differed between delivery groups ($p < 0.001$). The MCA PI was significantly lower in