Ramali Mendis, Christopher Flatley and Sailesh Kumar*

Maternal demographic factors associated with emergency caesarean section for non-reassuring foetal status

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Abstract

Objectives: This study aimed to determine maternal and obstetric factors associated with emergency caesarean section (CS) for non-reassuring foetal status (NRFS).
Materials and methods: This was a retrospective analysis of term singleton births between January 2007 and December 2015 at the Mater Mother's Hospital in Brisbane. The study group comprised all cases of emergency CS for NRFS, and the control cohort comprised all other births meeting the inclusion criteria but excluding those in the study cohort.
Results: Over the study period, there were 74,177 births fulfilling the inclusion criteria. The overall rate of emergency CS for NRFS was 4.2% (3132/74,177). Multivariate analysis showed that being overweight and obese, Indian and "other" ethnicity, artificial reproductive techniques, smoking, induction of labour and gestation at 39–42 weeks were associated with an increased risk, whereas being underweight, female sex, hypertension and birth without labour conferred a lower risk.
Conclusion: Many maternal and obstetric factors were associated with emergency CS for NRFS and influenced adverse perinatal outcomes. Recognition of these risk factors could help risk stratify women prior to labour.

Keywords: Caesarean section; foetal distress; maternal factors; non-reassuring foetal status; perinatal outcomes.

***Corresponding author: Sailesh Kumar,** Mater Research Institute – University of Queensland, Level 3 Aubigny Place, Raymond Terrace, South Brisbane, Queensland, QLD 4101, Australia, Tel.: +617 31638844, E-mail: sailesh.kumar@mater.uq.edu.au; and School of Medicine, The University of Queensland, Brisbane, Australia
Ramali Mendis: School of Medicine, The University of Queensland, Brisbane, Australia
Christopher Flatley: Mater Research Institute – University of Queensland, Level 3 Aubigny Place, Raymond Terrace, South Brisbane, Queensland, QLD 4101, Australia

Introduction

Intrapartum foetal hypoxia results in myocardial dysfunction, heart rate decelerations and redistribution of cardiac output towards the central nervous system [1, 2]. Why some fetuses are more prone to intrapartum compromise is not entirely clear. If not delivered rapidly enough, these babies are at risk of death or severe morbidity, including hypoxic brain injury with hypoxic ischaemic encephalopathy being the strongest and most consistent risk factor for cerebral palsy in term infants [3, 4]. In Australia, emergency caesarean rates for "foetal distress" range from 11% of all caesareans in Queensland to 16.3% in Tasmania [5]. The World Health Organization estimates that 4 million neonatal deaths are due to asphyxia [6], the majority of which occur in the low and middle income countries. Yet current antenatal risk classification systems fail to identify up to 63% of pregnancies that result in intrapartum hypoxia [7].

True or presumed intrapartum foetal compromise (IFC) is one of the most common indications for emergency caesarean section (CS) [8, 9], particularly in high-income countries where intrapartum foetal monitoring and ubiquitous access to anaesthetic staff, obstetric staff and surgical facilities are the norm. Without a doubt, a timely CS can prevent intrapartum death [10].

An emergency CS carries considerable more maternal and foetal risks, and these risks are generally related to the urgency for the need for delivery [11, 12]. In addition, perinatal outcomes are significantly worse when the primary indication for operative delivery is non-reassuring foetal status (NRFS) [9]. Although some general maternal and foetal risk factors for any emergency CS are known [3, 11], there is a paucity of data regarding specific factors or interactions associated with emergency CS for NRFS. Thus, the aim of the present study was to evaluate maternal and perinatal risk factors for emergency CS for NRFS in a large Australian cohort.

Materials and methods

This was a retrospective cohort study of all singleton emergency CS for NRFS at term (37–42 weeks) at the Mater Mother's Hospital in

Brisbane, Australia, between January 2007 and December 2015. This equates to almost one in six births in the state of Queensland and is therefore broadly representative of the general urban Australian population. Ethical and governance approvals for this study were granted by the Mater (HREC/14/MHS/37 and RG162) and the University of Queensland's (2015-SOMILRE-0133) Human Research Ethics and Governance Committees, respectively.

Data were collected from the hospital's maternity database and cross-referenced with the maternal and foetal medicine and neonatal databases to ensure consistency in reported outcomes. Inclusion criteria were non-anomalous singleton term pregnancies delivered by emergency CS where the primary indication for operative birth was recorded as NRFS. Exclusion criteria were multiple pregnancies, preterm gestation (<37 weeks), major congenital malformation, known aneuploidy or genetic syndromes and foetal demise prior to labour.

Given the retrospective nature of this study and the difficulty in applying a rigorous definition to the diagnosis of foetal compromise, we chose to adopt a pragmatic approach and used the primary indication for delivery/intervention as recorded in the perinatal database and cross-referenced this with the operative notes. We considered this definition reasonable, as the diagnosis of foetal compromise would generally have been made on the basis of an abnormal foetal heart pattern, foetal scalp pH or lactate, fully accepting the limitations of this methodology in our analysis. Maternal and perinatal factors evaluated included age, body mass index (BMI), birth weight, country of birth, ethnicity, public or private insurance, gestation at birth, conception by assisted reproductive techniques (ART), length of labour, onset of labour, foetal sex, maternal medical conditions (hypertension and diabetes), use of alcohol and smoking during pregnancy.

Perinatal outcomes analysed included admission to the neonatal intensive care unit (NICU), significant respiratory distress after birth, need for resuscitation, neonatal death prior to discharge, Apgar score <7 at 5 min and acidosis at birth (defined as cord pH < 7.1 or lactate ≥6 mmol/L or base excess ≤ –12 mmol/L).

Statistical analysis

The study group comprised all cases of emergency CS for NRFS, and the control cohort comprised all other births meeting the inclusion criteria but excluding those who had emergency CS for NRFS. Data integrity was assessed using a year-by-year analysis to identify inconsistencies of reporting between years. Where data integrity was questionable with sudden drops in outcomes that could not be accounted for by change in policy or treatment, those variables were excluded from any analysis. Efforts were made to correct missing and data entry errors through searches of individual patient records. Where data were collected with different degree of outcomes between years, these variables were collapsed into dichotomous variables to indicate whether the outcome occurred or not. Where only the outcomes were recorded, after discussion with data custodians, it was determined that it was reasonable to assume that missing data indicated that the outcome had not occurred.

Statistical analysis was performed using the Stata statistics program (StataCorp 2015, Stata Statistical Software: Release 14; StataCorp LP, College Station, TX, USA). Univariate analysis for categorical variables was performed using a chi-squared test or Fisher's exact test (if the expected cell frequencies were <5). Univariate analysis for non-normally distributed continuous variables was performed using Wilcoxon rank sum tests. A generalised linear model was completed for each variable individually with odds ratios (ORs). Multivariate analysis was performed using multiple logistic regressions for variables that were found to be significant on univariate analysis. A P-value <0.05 was considered statistically significant, and risks were expressed as OR with 95% confidence intervals (CIs). Summary statistics are reported as number (percentage) for categorical data, and median (interquartile range) for continuous data. Distribution of continuous variables was assessed using the Shapiro-Wilk test for normality.

Results

Over the study period, there were a total of 74,177 births fulfilling the inclusion criteria. The overall rate of emergency CS for NRFS was 4.2% (3132/74,177). Maternal demographics and obstetric variables are presented in Table 1, and perinatal outcomes are shown in Table 2. Table 3 shows the univariate analysis of the logistic regression models and the multivariate analysis with adjusted ORs. Figure 1A presents the proportion of births by emergency CS for NRFS stratified by gestation, and Figure 1B shows the adjusted ORs for emergency CS for NRFS by gestation.

Compared with the control group, women in the study cohort were more likely to be overweight or obese and be smokers. They were also more likely to be of Indian or "other" ethnicity and be born outside of Australia and were less likely to have either diabetes or hypertension. There was a lower proportion of women who had private health insurance that required delivery by emergency CS for NRFS. There was a later mean gestation at birth of the study cohort compared with the control group. The proportion of women who required emergency CS for NRFS was greater from 40 weeks onwards and less prior to this gestation compared with the control group. Emergency CS for NRFS was also significantly more common after induction of labour. The study cohort also had longer median length of labour.

Babies who were born by emergency CS for NRFS had lower mean birth weights compared with controls (3381.3 ± 508.2 g vs. 3463.7 ± 459.8 g, P < 0.001) and were more likely to be male (57.4% vs. 51.0%, P < 0.001). With the exception of neonatal death, babies in the study cohort had higher rates of admission to NICU, respiratory distress, requiring resuscitation, acidosis at birth, Apgar score <7 at 5 min and significant hypoglycaemia.

Following multivariate analysis, the following variables were associated with an increased risk of emergency CS for NRFS: BMI 25–30 kg/m^2 (overweight) (OR 1.29, 95% CI 1.17–1.42), BMI > 30 kg/m^2 (obese) (OR 1.50, 95% CI

Table 1: Maternal demographic and pregnancy factors associated with emergency caesarean section for intrapartum foetal compromise.

	Emergency CS for NRFS		P-value
	No (71,045)	Yes (n = 3132)	
Age[a]	31.3 ± 5.3	30.6 ± 5.4	<0.001
BMI[b]	22.8 (20.5–26.3)	23.4 (20.9–27.1)	<0.001
Normal	61.0% (42,744/70,111)	57.2% (1769/3095)	<0.001
Underweight	7.1% (4940/70,111)	5.7% (177/3095)	0.005
Overweight	19.7% (13,811/70,111)	22.2% (687/3095)	<0.001
Obese	12.3% (8616/70,111)	14.9% (462/3095)	<0.001
Hypertension	5.0% (3527/71,045)	3.3% (102/3132)	<0.001
Diabetes	6.3% (4450/71,045)	5.2% (162/3132)	0.01
Alcohol	18.0% (12,796/71,045)	18.3% (572/3132)	0.72
Smoking	16.9% (12,014/71,045)	19.2% (602/3132)	0.001
Born in Australia	64.6% (45,925/71,045)	58.0% (1816/3132)	<0.001
Born outside Australia	35.4% (25,120/71,045)	42.0% (1316/3132)	<0.001
Ethnicity			
Caucasian	72.4% (51,392/70,968)	64.6% (2018/3126)	<0.001
ATSI	1.7% (1185/70,968)	1.5% (46/3126)	0.39
Asian	11.6% (8263/70,968)	11.8% (369/3126)	0.78
Indian	2.5% (1805/70,968)	4.6% (143/3126)	<0.001
Other	11.7% (8323/70,968)	17.6% (550/3126)	<0.001
Insurance status			
Public	53.4% (37,954/71,045)	59.7% (1869/3132)	<0.001
Private	46.6% (33,091/71,045)	40.3% (1263/3132)	<0.001
Gestation at birth (weeks)[a]	39.1 ± 1.1	39.6 ± 1.2	<0.001
Birth at 37 weeks	7.8% (5568/71,045)	6.3% (198/3132)	0.002
Birth at 38 weeks	24.1% (17,110/71,045)	12.7% 397/3132)	<0.001
Birth at 39 weeks	30.1% (21,360/71,045)	20.7% (649/3132)	<0.001
Birth at 40 weeks	25.5% (18,098/71,045)	32.2% (1009/3132)	<0.001
Birth at 41 weeks	12.1% (8615/71,045)	26.8% (839/3132)	<0.001
Birth at 42 weeks	0.41% (291/71,045)	1.3% (40/3132)	<0.001
Birth at 43 weeks	0% (3/71,045)	0% (0/3132)	NA
ART	7.2% (5129/71,045)	7.7% (240/3132)	0.35
Length of labour (min)[b]	333 (197–524)	380 (242–565)	<0.001
Onset of labour			
Spontaneous	49.8% (35,368/71,043)	41.2% (1291/3132)	<0.001
Induction	27.0% (19,180/71,043)	52.9% (1658/3132)	<0.001
No labour CS	23.2% (16,495/71,043)	5.8% (183/3132)	<0.001

CS = caesarean section, NRFS = non-reassuring foetal status, ATSI = Aboriginal and Torres Strait Islander, BMI = body mass index, ART = assisted reproductive technologies.
Number represented by percentage (frequency/denominator).
[a]Normally distributed variable, mean ± SD.
[b]Non-normally distributed, median (IQR).

1.35–1.68), Indian ethnicity (OR 1.59, 95% CI 1.30–1.94), "other" ethnicity (OR 1.41, 95% CI 1.25–1.60), ART (OR 1.26, 95% CI 1.09–1.45), smoking (OR 1.14, 95% CI 1.03–1.25), induction of labour (OR 2.25, 95% CI 2.08–2.44), birth at 39 weeks (OR 1.41, 95% CI 1.24–1.60), birth at 40 weeks (OR 2.50, 95% CI 2.20–2.84), birth at 41 weeks (OR 3.91, 95% CI 3.42–4.49) and birth at 42 weeks (OR 5.40, 95% CI 3.77–7.75).

Variables associated with a lower risk of emergency CS for NRFS were as follows: BMI < 18.5 kg/m^2 (underweight) (OR 0.77, 95% CI 0.66–0.90), female sex (OR 0.67, 95% CI 0.62–0.73), hypertension (OR 0.72, 95% CI 0.59–0.89) and birth without labour (OR 0.42, 95% CI 0.36–0.50).

Discussion

The results from this large Australian study demonstrate a number of maternal and obstetric variables that are associated with emergency CS for NRFS. Our results are important in that they clearly identify specific risk factors

Table 2: Perinatal outcomes associated with emergency caesarean section for intrapartum foetal compromise.

	Emergency CS for NRFS		P-value
	No (71,045)	Yes (n=3132)	
Birth weight[a]	3463.7±459.8	3381.3±508.2	<0.001
Male	51.0% (36,237/71,045)	57.4% (1797/3132)	<0.001
Female	49.0% (34,808/71,045)	42.6% (1335/3132)	<0.001
NICU admission	1.2% (875/71,045)	4.7% (148/3132)	<0.001
Respiratory distress	3.7% (2659/71,045)	8.8% (274/3132)	<0.001
Resuscitation	33.4% (23,714/71,045)	65.2% (2042/3132)	<0.001
Neonatal death	0.14% (103/71,045)	0.2% (7/3132)	0.26
Acidosis at birth	1.1% (788/71,045)	4.9% (154/3132)	<0.001
Apgar <7 at 5 min	0.9% (651/71,045)	3.3% (102/3132)	<0.001
Hypoglycaemia	0.3% (210/71,045)	0.9% (27/3132)	<0.001

NICU = neonatal intensive care unit.
Number represented by percentage (frequency/denominator).
[a]Normally distributed variable, mean ± SD.

Table 3: Regression analysis of factors associated with emergency caesarean section for non-reassuring foetal status.

n=74,177	Unadjusted odds ratio (95% CI)	P-value	Adjusted odds ratio (95% CI)	P-value
BMI (normal BMI comparative)				
BMI underweight	0.87 (0.74–1.01)	0.07	0.77 (0.66–0.90)	0.001
BMI overweight	1.2 (1.09–1.32)	<0.001	1.29 (1.17–1.42)	<0.001
BMI obese	1.30 (1.17–1.44)	<0.001	1.50 (1.35–1.68)	<0.001
Country of birth (outside Australia vs. Australia)	1.32 (1.23–1.42)	<0.001	1.08 (0.98–1.20)	0.13
Ethnicity (Caucasian comparative)				
ATSI	0.99 (0.73–1.33)	0.94	0.86 (0.63–1.17)	0.33
Asian	1.14 (1.02–1.27)	0.03	1.11 (0.97–1.28)	0.14
Indian	2.02 (1.69–2.41)	<0.001	1.59 (1.30–1.94)	<0.001
Other	1.68 (1.53–1.85)	<0.001	1.41 (1.25–1.60)	<0.001
Method of conception (ART vs. spontaneous)	1.07 (0.93–1.22)	0.35	1.26 (1.09–1.45)	0.001
Gender (female cf. male)	0.77 (0.72–0.83)	<0.001	0.67 (0.62–0.73)	<0.001
Smoking	1.17 (1.07–1.28)	0.001	1.14 (1.03–1.25)	0.01
Hypertension	0.64 (0.83–0.79)	<0.001	0.72 (0.59–0.89)	0.002
Diabetes	0.82 (0.69–0.96)	0.01	0.88 (0.74–1.04)	0.13
Birth weight	0.9996 (0.9995–0.9997)	<0.001	0.999 (0.999–0.999)	<0.001
Labour (spontaneous comparative)				
Induced	2.37 (2.20–2.55)	<0.001	2.25 (2.08–2.44)	<0.001
No labour CS	0.30 (0.26–0.36)	<0.001	0.42 (0.36–0.50)	<0.001
Gestation at birth (38 weeks comparative				
37 weeks	1.53 (1.29–1.82)	<0.001	1.09 (0.91–1.31)	0.33
39 weeks	1.31 (1.15–1.49)	<0.001	1.41 (1.24–1.60)	<0.001
40 weeks	2.40 (2.14–2.70)	<0.001	2.50 (2.20–2.84)	<0.001
41 weeks	4.20 (3.71–4.74)	<0.001	3.91 (3.42–4.49)	<0.001
42 weeks	5.92 (4.19–8.37)	<0.001	5.40 (3.77–7.75)	<0.001
43 weeks	NA	NA	NA	NA

CS = caesarean section, ATSI = Aboriginal and Torres Strait Islander, BMI = body mass index, ART = assisted reproductive technologies.
The following independent variables were considered for the model: BMI categories compared to normal BMI range, country of birth outside of Australia compared to Australia as the country of birth, ethnicity was compared to the Caucasian/European group, artificial reproductive technique compared to spontaneous conception, female gender compared to male, smoking, hypertension, diabetes, birth weight as a continuous variable, induction of labour and no labour compared to spontaneous onset of labour and gestation by week compared to 38 weeks gestation. Only the variables that had a P-value <0.05 were considered significant in the final fit model.

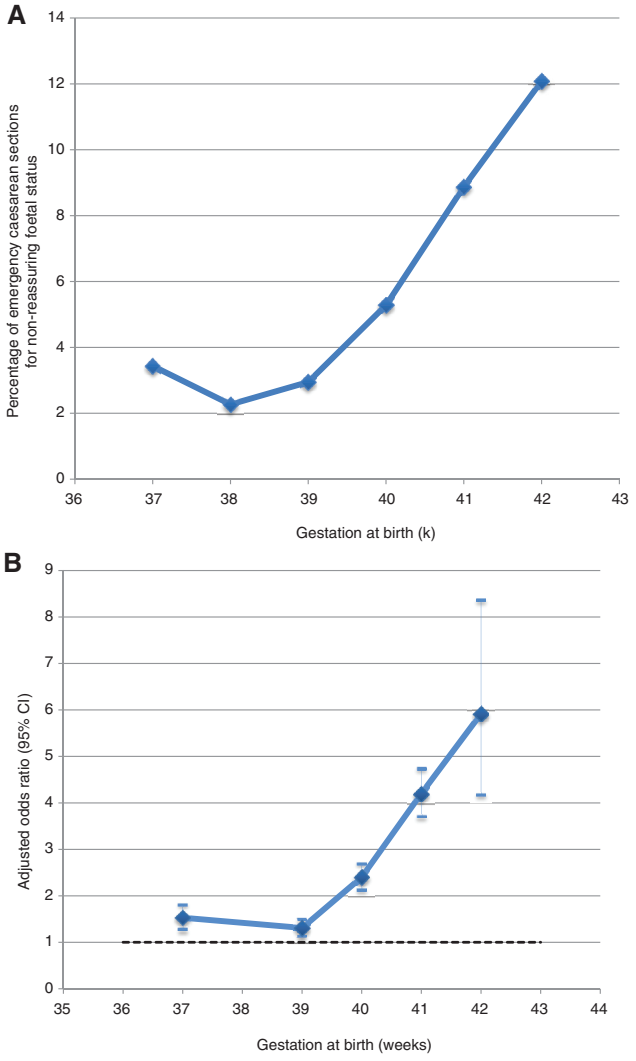

Figure 1: Emergency caesarean sections for non-reassuring foetal status by gestation.
(A) Percentage of deliveries for non-reassuring foetal status stratified by gestation. (B) Adjusted odds ratio for emergency caesarean section for non-reassuring foetal status stratified by gestation.

relevant to an Australian population – to our knowledge these data have not previously been reported for this specific indication for emergency CS.

Many of the maternal variables we demonstrate in this study such as raised BMI are common to any emergency CS [13, 14], and these may be confounded by the presence of co-existing medical conditions (diabetes, hypertension/preeclampsia) [14]. In our study, however, after controlling for some of these confounders, we found that surprisingly, both hypertension and diabetes were associated with decreased odds of emergency CS for NRFS. One reason for this may be the fact that these women with these conditions are induced earlier in term when the risk of IFC is lower. Our study cohort also had a higher proportion of other demographic factors such as smoking in pregnancy, country of birth outside of Australia and ethnicity other than Caucasian. Indian and "other" ethnicity in particular were associated with an increased risk for emergency CS for NRFS. We also found that the proportion of publicly funded patients was higher in the study cohort compared with the control group. Although private health insurance status may be a proxy for some sociodemographic variables (e.g. socioeconomic status, general maternal health, smoking status etc.), the associations were detected after multivariate analyses had taken into account any confounding effects they may have had. Interestingly, we demonstrate an increased risk for emergency CS for NRFS from 39 weeks onwards. The reasons for this are not clear, but one possible reason may be the deterioration in placental function with increasing gestation.

The results from our study and others clearly show that emergency CS for NRFS is associated with poorer perinatal outcomes [9, 15] and emphasise the need for careful consideration of maternal and obstetric risk factors that may lead to such a consequence. Knowledge of the risk of IFC could influence the choice of both mode and timing of birth. Women at significant risk of IFC could be offered elective birth, which could reduce the number of emergency CSs performed and possibly improve maternal and neonatal outcomes. Emergency procedures often carry more risk of complications, more parental anxiety, cost more and often occur out of hours when staffing is less than optimal. The assignment of women to a "low risk" category would also allow maternity care to be individualised. The majority of women who are deemed to be low risk for foetal compromise could be given the option of birth without continuous electronic foetal monitoring either in a midwifery unit or possibly at home (depending on the health care setting).

There is currently much interest in identifying pregnancies at risk of adverse outcomes at term, particularly stillbirth or serious neonatal morbidity. A recently published report [16] (Every Baby Counts) by the Royal College of Obstetricians and Gynaecologists in the UK showed that in 2015, more than 1000 term babies either died or suffered significant brain injury as a consequence of problems in labour and highlights the importance of both identification of vulnerable fetuses as well intrapartum processes to reduce risk of adverse events. Such methods have included assessing the foetal cerebroplacental ratio [17, 18], umbilical venous flow rate [19] and measurement of biochemical markers of placental dysfunction [20, 21] in order to identify fetuses at potentially increased risk of intrapartum complications. Although acute intrapartum

events severe enough to cause profound hypoxia or death in the fetus are fortunately relatively rare at term, suboptimal intrapartum care or failure to recognise signs of developing foetal compromise is not. In the United States, it is estimated that the complication rate during labour and delivery is 2.8%, with 10% of adverse events associated with serious disability [22]. Hankins et al. [23] hypothesised that if a near universal CS for all women at 39 weeks was performed in the USA, this would theoretically prevent 6000 stillbirths annually and would reduce by 83% the number of newborns with moderate or severe neonatal hypoxic encephalopathy. Although this is clearly not a practical solution for all women, it may not be unreasonable that for some women who are at very high risk of IFC this may be one option to improve outcomes. Conversely, in healthcare settings with only limited resources for intrapartum monitoring, a more liberal use of CS to deliver babies that are at high risk of intrapartum compromise will certainly increase the overall rates of operative delivery, but in these countries, operative delivery rates are probably too low and a slight increase could potentially translate into tangible improvements in perinatal outcomes.

Our results highlight the importance of recognising risk factors for emergency CS for NRFS and potentially allow risk stratification to be individualised to mitigate the perinatal consequences of this intervention at term.

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Author's statement

Conflict of interest: Authors state no conflict of interest.

Material and methods: Informed consent: Informed consent has been obtained from all individuals included in this study.

Ethical approval: The research related to human subject use has complied with all the relevant national regulations, and institutional policies, and is in accordance with the tenets of the Helsinki Declaration, and has been approved by the authors' institutional review board or equivalent committee.

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