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ORIGINAL ARTICLE

Neonatal outcomes after introduction of a national intrapartum fetal surveillance education program: a retrospective cohort study

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Abstract

Objective: To determine the impact of a multidisciplinary fetal surveillance education program (FSEP) on term neonatal outcomes.
Methods: A retrospective cohort study of term neonatal outcomes before (1998–2004) and after (2005–2010) introduction of a FSEP. Clinical data was collected for all term infants admitted to a neonatal intensive care unit (NICU) in Australia between 1998 and 2010. Infants with congenital abnormalities were excluded. Neonatal mortality and severe neonatal morbidity (admission to a NICU, respiratory support, hypoxic encephalopathy) were compared before and after the FSEP was introduced. The rates of operative delivery during this time were assessed.
Results: There were 3 512 596 live term births between 1998 and 2010. The intrapartum hypoxic death rate at term decreased from 2.02 to 1.07 per 10 000 total births. More neonates were admitted to NICU after 2005 (10.6 versus 14.6 per 10 000 live births), however fewer babies admitted to the neonatal unit had Apgar scores <5 at five minutes (55.1–45.5%, RR 0.82, 95% CI 0.7–0.87); and rates of hypoxic ischemic encephalopathy fell from 36% to 30% (RR 0.83, 95% CI 0.76–0.90). There was no increase in rates of emergency in labour caesarean sections (11.7% pre versus 11.1% post, RR 0.95, 95% CI 0.95–0.96).
Conclusions: Introduction of a national FSEP was associated with increased neonatal admissions but a reduction in intrapartum hypoxia, without increasing emergency caesarean section rates.

Keywords

Fetal monitoring, intrapartum, neonatal outcome, hypoxic ischemic encephalopathy

History

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Introduction

Intrapartum hypoxia is a major cause of neonatal morbidity and mortality, and the leading cause of litigation in obstetric care [1]. Monitoring the fetal heart rate pattern in labour aims to identify those fetuses at risk of hypoxia and acidemia, in order to achieve a timely delivery to prevent neurological complications [2]. Electronic fetal monitoring (EFM) is in ubiquitous use in developed countries, where it has been shown to reduce neonatal seizures but not neonatal deaths or long-term neurological sequelae [3]. However, prevention of hypoxic injury relies on accurate interpretation of EFM by the care provider and appropriate obstetric intervention. Failure to accurately interpret and act on abnormal fetal heart rate patterns has been implicated in up to 50–70% of intrapartum fetal deaths, as well as 65% of neonatal encephalopathy and is the leading cause of litigation in the US and UK [4,5].

In response to this high proportion of potentially preventable adverse perinatal events, in otherwise healthy term pregnancies, national governing bodies have developed guidelines and credentialing for intrapartum fetal monitoring [6]. The Royal Australian and New Zealand College of Obstetricians and Gynaecologists (RANZCOG) published an intrapartum fetal surveillance guideline and algorithm to guide maternity care providers on intrapartum risk identification, methods of surveillance and management of suspected fetal compromise [7]. The current guideline can be accessed at http://www.fsep.edu.au/publications. However, the success of guidelines relies on universal education of the maternity workforce and active implementation through education. Therefore, in 2004 the RANZCOG introduced the fetal surveillance education program (FSEP), to standardise the education and credentialing of maternity care providers in Australia and New Zealand. The guideline was updated in 2006 and 2014 [8,9].

The FSEP consists of a full day multidisciplinary face-to-face education program complimented by online and hard copy resource materials. Course content is evidence-based and focused on improving the participants understanding of fetal and utero-placental physiology and its relevance to changes in the fetal heart rate pattern. This forms the basis of interpretation of both normal and abnormal cardiotocography

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(CTG) and subsequent intrapartum management required. The aim is to ultimately improve the care-providers capacity to respond appropriately to suspected fetal compromise. The course is taught using a combination of didactic lectures and multidisciplinary workshops. Participants are required to complete a credentialing assessment on completion of the course and reach a level deemed appropriate for their scope of practice. Annual credentialing is recommended by attendance at a face-to-face refresher course or completion of an online education course and assessment.

Whilst fetal surveillance education has been shown to improve neonatal outcomes at an institutional level, there is a paucity of data on the effectiveness of training and credentialing at a national level [10–12]. The FSEP is highly valued by users and the assessment tools valid and reliable [13–15]. However, the efficacy of the FSEP to improve perinatal outcomes has not been evaluated. We compared adverse neonatal outcomes in term infants delivered in Australia before and after the introduction of FSEP, to determine the effectiveness of the multidisciplinary training program to improve identification of the compromised fetus and reduce neonatal morbidity associated with intrapartum hypoxia. Since it has been suggested that continuous intrapartum fetal surveillance increases obstetric intervention, we also examined the impact on caesarean section and operative delivery rates.

Materials and methods

We used retrospective cohort data to perform an analysis of outcomes for term neonates before and after implementation of the FSEP in Australia.

Data was obtained from both the Australian and New Zealand Neonatal Network (ANZNN) and the National Perinatal Epidemiology and Statistics Unit (NPESU) on all live births and term neonatal admissions between 1998 and 2010. The ANZNN monitors the mortality and morbidity of newborn infants by collecting data on all babies admitted to a neonatal intensive care unit (NICU). Data was collected on term infants that received four or more hours of assisted ventilation (or died prior to four hours of age) or received therapeutic hypothermia (after 2007). The NPESU compiles a validated national dataset on all births reported in each state and territory in Australia. Infants were included in this study if they were $\geq 37+0$ weeks gestation and required admission to a NICU for ventilation or therapeutic hypothermia. Infants with a known congenital abnormality were excluded.

The FSEP was introduced throughout Australia in 2005 and therefore we compared neonatal outcomes before (1 January 1998 to 31 December 2004) and after its introduction (1 January 2005 to 31 December 2010). The FSEP organisers provided data on participation at FSEP courses, including a breakdown based on discipline (midwifery versus medical staff-consultants, registrars, residents). Participation is mandatory for doctors enrolled in the RANZCOG training program.

This study was reviewed and approved by the Mercy Health Human Ethics Committee (R12/53).

The main outcome studied was perinatal mortality in the two cohorts. Data on cause of perinatal deaths was only available from 2001 onwards (PSANZ criteria). Data on cause of perinatal death at term was only available after 2003. Death due to intrapartum hypoxia was defined as intrapartum fetal death where the fetus was alive at the onset of labour and there were intrapartum complications resulting in evidence of non-reassuring fetal status in a normally grown infant (PSANZ). Neonatal deaths due to HIE and or intrapartum hypoxia were included when there was evidence of metabolic acidosis in the fetus (at postmorterm), umbilical artery cord blood analysis or early neonatal evidence of severe metabolic acidosis. Neonatal mortality was defined as death of a live born baby during NICU admission (ANZNN). Secondary outcomes were those contributing to neonatal morbidity: Apgar at 1 and 5 min; admission to NICU; need for intubation; duration of ventilatory support; type of ventilatory support (high flow oxygen, continuous positive airway pressure, invasive ventilator support via endotracheal/nasotracheal intubation, high frequency oscillatory ventilation); indication for respiratory support.

Hypoxic ischemic encephalopathy (HIE) was defined as a syndrome of disturbed neurological function (severe encephalopathy $\pm$ seizures) with evidence of birth asphyxia (metabolic acidemia, Apgar <5 at 5 min, base excess >-12 mmol/L). Therapeutic hypothermia was recommended for babies born with HIE after 2007 as per local and national guidelines. Meconium aspiration was defined as respiratory distress presenting up to 12 h after birth, often with signs of birth asphyxia, with consistent chest X-ray findings (overexpansion, widespread coarse infiltrates).

To determine the impact on caesarean section rates and instrumental deliveries we also assessed mode of delivery in both the study and national populations.

Due to pragmatic reasons we compared outcomes of women before and after the introduction of the FSEP. For each time period we calculated the number and percentage of neonates and mothers with the primary and secondary outcomes. Independent sample *t*-tests were used to compare normally distributed continuous variables. The χ^2 test and Fisher's exact test with Yates correction was used to compare categorical data. We report relative risk reductions with 95% confidence intervals. We considered a $p<0.05$ to be significant. All analyses were performed in SPSS (Version 22) (SPSS Inc., Chicago, IL) and Graphpad Prism (Version 5, La Jolla, CA).

Results

There were a total of 3 512 596 term births during the study period: 1 606 128 occurred before the introduction of the FSEP (1 January 1998–31 December 2004) and 1 906 488 after (1 January 2005–31 December 2010). There was a reduction in the rate of term hypoxic intrapartum perinatal deaths from 2.02 to 1.07 per 10 000 total births after 2005 (RR 0.49, 95% CI 0.35–0.68). Neonatal mortality amongst babies admitted to the neonatal unit fell from 14.7% to 11.2%, RR 0.76, 95% CI 0.65–0.89). However, there was no overall decrease in total neonatal deaths (1.5 per 10 000 to 1.6 per 10 000, RR 1.04, 95% CI 0.88–1.23). There was an increase in the number of neonates requiring admission to a NICU for respiratory support or therapeutic hypothermia from 10.6 to 14.6 per 10 000 live births (RR 1.37, 95% CI 1.29–1.46).

Attendance at FSEP education courses was consistently high among medical staff from 2005, with 342 attending in 2005 and 339 in 2011. Attendance by midwifery staff rose rapidly from 1372 in 2005 to 2111 in 2006, and then steadily increased to 2727 in 2011 (Figure 1). In 2011, there were 2367 registered midwives in Australia, suggesting a high compliance among midwives and midwifery students (not included in the 2367, but encouraged to attend the course prior to registration).

Babies requiring admission to a NICU had a gestational age of 39.5 weeks (±1.3 weeks). Compared to all livebirths, babies admitted to the NICU were more likely to be male (58% versus 51%, $p < 0.001$) and small for gestational age (16.7% versus 4.9%, $p < 0.001$). There was no difference in gestational age, birthweight, sex, small for gestational age (<2.5 kg) or large for gestational age babies (>4 kg) for babies admitted to NICU before and after introduction of the FSEP (Table 1).

Table 2 presents the neonatal outcomes before and after the introduction of FSEP in babies admitted to the neonatal unit.

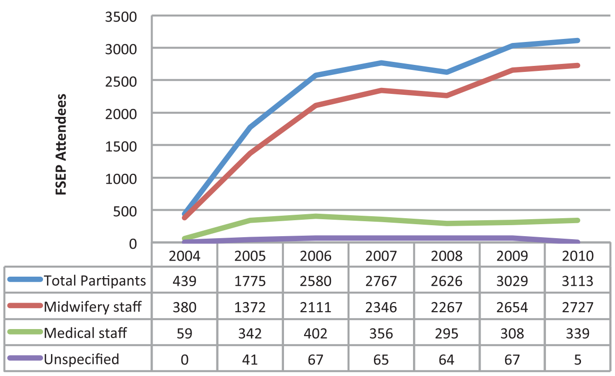

Figure 1. Attendance at FSEP courses by participant discipline from a pilot study in 2004 to nationwide training from 2005 to 2010.

Table 1. Characteristics of neonates admitted to the NICU before (1998–2004) and after (2005–2010) introduction of the FSEP.

Characteristic	Before FSEP ($n = 1703$)	After FSEP ($n = 2775$)
Gestational age (weeks)	39.4 (1.3)	39.5 (1.3)
Birthweight (g)	3418 (606)	3427 (588)
Small for gestational age	270 (16.7%)	466 (16.8%)
Large for gestational age	146 (8.6%)	225 (8.1%)
Sex (% male)	967 (56.8%)	1631 (58.8%)

Data is mean (S.D.) or n (%) unless stated.

Despite the overall increase in admitted babies, the proportion of babies with Apgar <5 at 5 min decreased from 55.7% to 45.5% (RR 0.82, 95% CI 0.7–0.87). Fewer babies required intubation for ventilator support: 55.1% versus 45.9% (RR 0.83, 95% CI 0.79–0.88). The duration of ventilator support fell from 6.2 days to 5.7 days ($p < 0.01$). Prior to 2005, 36.1% of babies were diagnosed with HIE. This fell to 29.8% after introduction of the FSEP (RR 0.83, 95% CI 0.76–0.90). Meconium aspiration rates slightly increased from 28% to 32% (RR 1.15, 95% CI 1.05–1.27) and TTN increased from 7% to 16% (RR 2.29, 95% CI 1.89–2.78). Therapeutic hypothermia for perinatal asphyxia was introduced in 2007, with a total of 404 babies (22% of post FSEP cohort) receiving it. Data on how many neonates would have been eligible for therapeutic hypothermia in the pre FSEP cohort was not available.

Table 3 presents maternal outcomes in the neonates requiring NICU admission and national data. In the post FSEP cohort, more babies admitted to the NICU were delivered by caesarean section (28% versus 34%, RR 1.20, 95% CI 1.09–1.32). However, the national rates of emergency caesarean section in labour did not increase across this time (11.7% pre versus 11.1% post, RR 0.95, 95% CI 0.95–0.96). Neither did the national rates of instrumental delivery increase (11.0% pre versus 11.2% post, RR 1.01, 95% CI 0.98–1.03). There was no difference in the numbers of NICU admitted babies delivered by instrumental delivery (15.8% versus 15.9%, RR 1.00, 95% CI 0.87–1.19). The fall in spontaneous vaginal birth during this time was largely due to an increase in pre-labour caesarean sections.

Discussion

This large population-based study showed a reduction in term perinatal mortality and morbidity, without an increase in obstetric intervention, after implementation of a national multidisciplinary FSEP in babies admitted to the neonatal unit. We found a 51% reduction in the risk of intrapartum fetal death, attributed to intrapartum fetal hypoxia, after introduction of the education program. Neonatal morbidity amongst babies admitted to the neonatal unit was improved with the number of babies born with an Apgar <5 at 5 min decreased by 18% and cases of HIE reduced by 17%. In contrast to previous studies, we did not find an increase in intrapartum caesarean section rates or operative vaginal deliveries, after introduction of the FSEP.

Intrapartum fetal surveillance using EFM is the current gold standard to identify the fetus at risk of intrapartum hypoxia and acidosis. The efficacy of EFM to accurately

Table 2. Neonatal outcomes before (1998–2004) and after (2005–2010) introduction of the FSEP among babies requiring neonatal admission.

Outcome	Before FSEP ($n = 1703$)	After FSEP ($n = 2775$)	p values	Relative risk (95% CI)
Apgar of 0 at 1 min	203 (11.9)	265 (9.5)	<0.0001	0.91 (0.88–0.94)
Apgar <5 at 5 min	948 (55.7)	1264 (45.5)	<0.0001	0.82 (0.7-0.87)
Intubation and ventilator support	938 (55.1)	1275 (45.9)	<0.0001	0.83 (0.79–0.88)
HIE	615 (36.1)	827 (29.8)	<0.0001	0.82 (0.76–0.89)
Meconium aspiration	470 (27.6)	883 (31.8)	0.003	1.15 (1.04–1.27)
TTN	119 (6.9)	444 (16)	<0.0001	2.29 (1.88–2.78)

CI: confidence interval; HIE: hypoxic ischemic encephalopathy; TTN: transient tachypnoea of the newborn.
Data are n (%).

Table 3. Obstetric interventions before (1998–2004) and after (2005–2010) introduction of the FSEP.

	Total confinements				Babies admitted to NICU			
Obstetric intervention	Before FSEP ($n = 1764339$)	After FSEP ($n = 1716235$)*	p	RR (95%CI)	Before FSEP ($n = 1703$)	After FSEP ($n = 2775$)	p	RR (95%CI)
Intrapartum caesarean section†	117463 (11.7)	218967 (11.1)	<0.0001	0.95 (0.95–0.96)	477 (27.9)	932 (33.5)	0.0001	1.20 (1.09–1.32)
Instrumental delivery	193823 (11.0)	193977 (11.3)	<0.0001	1.03 (1.02–1.04)	270 (15.7)	439 (15.8)	0.99	1.00 (0.87–1.15)
Spontaneous vertex delivery	1115069 (63.2)	987051 (57.5)	<0.0001	0.85 (0.85–0.85)	733 (43.0)	1071 (38.5)	0.004	0.89 (0.83–0.96)

CI: confidence interval.
Data are *n* (%).
*Denominator is number of confinements.
†Intrapartum caesarean section data only available from 2001. The denominator for 2001–2004 was 1 006 284.

predict neonatal outcomes has been questioned and EFM has been reported to increase operative deliveries without a concomitant decrease in adverse neonatal outcomes [3]. However, there are concerns about the quality and sample size of studies included in this Cochrane review, and recent large population studies have found a reduction in neonatal mortality and morbidity with the use of EFM, but at the cost of an increase in operative deliveries [10,16].

The efficacy of EFM is hampered by variation in inter-observer and intra-observer interpretation of fetal heart rate patterns [17,18]. Intrapartum fetal surveillance guidelines aim to standardise the interpretation of EFM and reduce this variation [1,11]. Whilst guideline based practice has been shown to improve patient safety and reduce litigation, passive implementation of guidelines has minimal effect on patient outcomes [19,20]. In contrast, active implementation, such as with the FSEP, which uses face to face teaching supported by online and hard copy resources, improves patient safety by providing a common approach to interpretation based on fetal physiology, ensuring consistent terminology and improved communication between maternity care providers. These improvements in teamwork and communication are key to enhancing patient safety, as has been demonstrated in obstetric emergency skills training and simulation programs [12,21]. Pre and post FSEP course assessments have demonstrated an improved understanding of intrapartum fetal surveillance and a high degree of participant satisfaction in the course [13]. We are now able to demonstrate that this may also positively impact on patient care.

In addition to interpretation of EFM, the program provides a framework for management of suspected fetal compromise. This includes judicious use of oxytocics, intrauterine resuscitative methods and prompt escalation of care to senior midwifery and medical staff when fetal compromise is suspected. In contrast to previous studies, we found no increase in overall operative delivery rates after introduction of the FSEP [10]. A criticism of EFM is the high rate of false positives, demonstrated by only 4–10% of intrapartum caesarean sections for suspected fetal compromise actually having evidence of hypoxia/acidosis ($pH < 7.0$) [22]. Our study suggests that improved interpretation of EFM may therefore reduce the number of unnecessary operative deliveries by reducing the number of false positives, whilst ensuring operative deliveries occurred in timely fashion for those babies at real risk of hypoxia.

Despite the promise of improved outcomes with intrapartum fetal surveillance education, not all cases of intrapartum hypoxia are or will be identified. Efforts must continue to improve detection of pregnancies at risk of intrapartum hypoxia. For example, 14% of babies requiring admission to NICU were small for gestational age compared to only 3% of babies not admitted. These babies are at high risk of intrapartum hypoxia and therefore efforts to improve detection of these pregnancies prior to the onset of labour are essential to ensure they are appropriately monitored and managed.

An important strength of this study was the large sample size. This study included all term neonatal admissions in Australia from 1998 to 2010. Data was entered directly by the neonatal units into a web-based data collection system and was not obtained from ICD-10 coding or discharge summaries, an approach designed to improve the validity of data collection. Whilst retrospective studies such as this can only suggest association, we not only found a decrease in mortality but also an improvement in indicators of possible intrapartum hypoxia (Apgars, HIE, respiratory requirements). That we observed improved results across a spectrum of outcomes increases our confidence that the changes may reflect a cause-and-effect relationship.

However, several limitations must be acknowledged. Despite the improvements in neonatal outcomes in babies admitted to the neonatal unit there was no overall improvement in neonatal mortality. It was not possible to obtain data for those babies not requiring neonatal admissions or to link the neonatal data to changing maternal demographics, use of oxytocinon/induction or assess the knowledge of individual maternity care providers involved. It is possible that other factors influenced obstetric care over the time period that are independent of improved intrapartum fetal surveillance.

Importantly, there was an overall increase in neonatal admissions across the study period. This may represent increased suspicion of fetal compromise and a more proactive approach to increased surveillance of these neonates. It may also reflect changing patient demographics and an increased proportion of high-risk pregnancies. Less babies required ventilatory support for HIE and in contrast more babies required ventilatory support for TTN, which may reflect the increased caesarean section rate in those babies admitted to the neonatal unit. However, although there was an improvement in the proportion of babies in the neonatal unit suffering intrapartum related hypoxia, the absolute numbers of babies affected rose over the time period. The improved neonatal mortality in babies admitted to the neonatal unit after 2005 may not be due to improved perinatal condition of babies but may also be accounted for by the introduction of therapeutic cooling and improvements in neonatal care. Although we are able to show an improvement in early neonatal morbidity, we do not have data to demonstrate whether there was any reduction in the long-term sequelae of intrapartum hypoxia. Unfortunately, data on the cause of *term* stillbirths, classified according to PSANZ criteria, was only available from 2003 onwards. Prior to this preterm and term intrapartum deaths were considered together, but there was an overall reduction in all intrapartum hypoxic deaths gestations after 2005 (3.2–0.3%). Whether improved fetal surveillance may have affected preterm intrapartum deaths is beyond the scope of this study.

New diagnostic modalities, must continue to be developed and trialled to improve the accuracy of diagnosing intrapartum hypoxia. But any advances must also be accompanied by effective education of the entire maternity workforce and the efficacy of these interventions assessed prior to widespread implementation [23,24]. Cluster RCTs with long term neonatal follow up are required to analyse the efficacy of new modalities and education interventions to improve perinatal outcomes, but such randomised trials will continue to be limited by the large sample size required to demonstrate an improvement in rare perinatal outcomes such as intrapartum hypoxia.

Conclusion

We have shown that a national multidisciplinary education program targeting interpretation and management of intrapartum fetal monitoring may be associated with improved neonatal outcomes, without increasing the rates of operative delivery. Such programs should be mandatory for all maternity care providers and ongoing assessments undertaking to ensure currency. Implementation of education programs requires ongoing evaluation to ensure their efficacy in improving outcomes for both mothers and babies.

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Declaration of interest

Prof Permezel is the current president of the RANZCOG but has not been involved in the conception and running of the FSEP, or any financial gain.

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Ethics approval

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