

OBSTETRICS

Contributory factors and potentially avoidable neonatal encephalopathy associated with perinatal asphyxia

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BACKGROUND: The recently published monograph, Neonatal encephalopathy and neurologic outcome, from the American College of Obstetricians and Gynecologists calls for a root cause analysis to identify components of care that contributed to cases of neonatal encephalopathy to design better practices, surveillance mechanisms, and systems. All cases of infants born in New Zealand with moderate and severe neonatal encephalopathy were reported to the New Zealand Perinatal and Maternal Mortality Review Committee from 2010. A national clinical review of these individual cases has not previously been undertaken.

OBJECTIVES: The objective of the study was to undertake a multidisciplinary structured review of all cases of neonatal encephalopathy that arose following the onset of labor in the absence of acute peripartum events in 2010–2011 to determine the frequency of contributory factors, the proportion of potentially avoidable morbidity and mortality and to identify themes for quality improvement.

STUDY DESIGN: National identification of, and collection of clinical records on, cases of moderate or severe neonatal encephalopathy occurring after the onset of labor in the absence of an acute peripartum event, excluding those with normal gases and Apgar scores at 1 minute, among all cases of moderate and severe neonatal encephalopathy at term in New Zealand in 2010–2011 was undertaken. Cases were included if they had abnormal gases as defined by any of pH of ≤ 7.2 , base excess of ≤ -10 , or lactate of ≥ 6 or if there were no cord gases, an Apgar score at 1 minute of ≤ 7 . A clinical case review was undertaken by a

multidisciplinary team using a structured tool to record contributory factors (organization and/or management, personnel, and barriers to access and/or engagement with care), potentially avoidable morbidity and mortality and to identify themes to guide quality improvement.

RESULTS: Eighty-three babies fulfilled the inclusion criteria for the review, 56 moderate (67%) and 27 severe (33%), 21 (25%) of whom were deceased prior to hospital discharge. Eighty-four percent of 64 babies with cord gas results had one of pH of ≤ 7.0 , base excess of ≤ -12 , or lactate of ≥ 6 ; and 42% (8 of 19) without cord gases had 5 minute Apgar scores < 5 . Excluding 5 babies who died within a day of birth, all but 1 baby were admitted to a neonatal unit within 1 day of birth. Contributory factors were identified in 84% of 83 cases, most commonly personnel factors (76%). Fifty-five percent of cases with morbidity or mortality were considered to be potentially avoidable, and 52% of cases were considered potentially avoidable because of personnel factors. The most frequently identified theme related to the use and interpretation of cardiotocography in labor.

CONCLUSION: A multidisciplinary case review of neonatal encephalopathy following apparently uncomplicated labor identified a high rate of potentially avoidable morbidity and mortality and issues amenable to quality improvement such as multidisciplinary training of staff in fetal surveillance in labor.

Key words: contributory factors, maternity, neonatal encephalopathy, perinatal asphyxia, potentially avoidable, review

Reviews of care among cases of neonatal encephalopathy (NE) from Europe and South Africa have reported substandard pregnancy care, most often related to care provided by health professionals, including issues with risk assessment and fetal monitoring.¹⁻³ Furthermore, the recently published monograph, Neonatal encephalopathy and neurologic outcome, from the American College of Obstetricians and Gynecologists calls for a root cause analysis to identify components of care that contributed to cases of NE to

design better practices, surveillance mechanisms, and systems.⁴

The Neonatal Encephalopathy Working Group (NEWG) of the Perinatal and Maternal Mortality Review Committee (PMMRC) of New Zealand has prospectively collected data on cases of moderate and severe NE at term in New Zealand since 2010.^{5,6} The PMMRC is required to report mortality and morbidity of mothers and babies in New Zealand and by critical analysis identify areas in which there may be potential for improvement of services and outcomes. However, to date there has been no detailed review of individual NE case records to elicit contributory factors and estimate potential avoidability.

New Zealand has approximately 65,000 births annually. The maternity model of care in 2010 involved a self-employed midwifery lead maternity carer for 80% of women, a private

obstetrician for 6%, a general practitioner for 1.5%, and a hospital primary midwife, secondary care, or no antenatal care for 15%. Whereas the responsibility for care sits with the lead maternity carer, there are clear guidelines for referral to an obstetrician and responsibility for care may therefore change during pregnancy or in labor as required and on discussion with the woman and her caregiver. In 2011 in New Zealand, 3.3% of babies were born at home and 10.1% in primary facilities compared with 40.9% in secondary hospitals and 45.7% in tertiary level facilities.

The aim of the current study was to undertake a structured multidisciplinary review of individual cases to determine whether there were contributory factors to death and morbidity from NE, whether death or the severity of morbidity could have been prevented, and to identify areas in

Cite this article as: Sadler LC, Farquhar CM, Masson VL, et al. Contributory factors and potentially avoidable neonatal encephalopathy associated with perinatal asphyxia. *Am J Obstet Gynecol* 2016;xxx:xx-xx.

0002-9378/\$36.00

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<http://dx.doi.org/10.1016/j.ajog.2015.12.037>

which improvements to maternity and neonatal care in New Zealand might reduce the rate and morbidity from NE.

The study aimed to undertake multidisciplinary clinical case review of pregnancies resulting in NE, in which the encephalopathy was considered to be the result of events occurring during the intrapartum period but not because of acute peripartum events.

The specific objectives of the review among this group of cases were to determine the rate of contributory factors (organization and/or management, personnel, and barriers to access and/or engagement with care), the rate of potentially avoidable mortality or morbidity, and to identify key areas in which quality improvement initiatives should focus resource.

Materials and Methods

Cases in 2010–2011 for multidisciplinary review were identified from the national database of term babies born with moderate or severe NE. The time period 2010–2011 was chosen because full data were available for this cohort. NE was defined, for the national collection, as a clinically defined syndrome of disturbed neurological function within the first week of life in the term infant (≥ 37 weeks' gestation), manifested by difficulty in initiating and maintaining respiration, depression of tone and reflexes, subnormal level of consciousness, and often seizures.⁷ Only Sarnat moderate and severe cases were included.⁷

Cases were identified and reported by pediatricians via the New Zealand Pediatric Surveillance Unit methodology, a well-established and effective mechanism for collection of data on uncommon pediatric disorders. To ensure full case ascertainment, key clinicians were also identified and asked to provide details of all cases that met the definition in their hospitals. Term neonatal hypoxic peripartum and/or hypoxic ischemic encephalopathy deaths in the PMMRC data set, validated against national health and mortality data sets, were also included if not already identified via the New Zealand Pediatric Surveillance Unit.

The cases were limited to those born by emergency cesarean delivery (CD), operative vaginal, or unassisted vaginal birth after laboring without an identified acute event in labor (cord prolapse, abruption, uterine rupture, shoulder dystocia, vasa previa, head entrapment with breech, maternal collapse, or arrest), who had abnormal (or no) blood gases (defined as any of pH of ≤ 7.2 , base excess of ≤ -10 , or lactate of ≥ 6) at birth and/or an Apgar score at 1 minute of ≤ 7 . These cases were chosen for review because there was no obvious cause for the NE and it was hypothesized significant learnings might arise from review.

The case reviews followed the methodology developed by the PMMRC for the review of maternal mortality⁸ since used for maternal morbidity and perinatal mortality,^{5,6,9} using a checklist tool (Table 1) to identify contributory factors and potentially avoidable mortality/morbidity. The review utilized copies of all case notes and data collected from the submitted forms covering antenatal care, intrapartum care, neonatal resuscitation, and early neonatal management.

The review teams were multidisciplinary and included pediatricians, neonatologists, neonatal nurse practitioners, obstetricians, and midwives. Every case review included at least 1 representative from pediatrics, obstetrics, and midwifery. Clinicians did not perform a review of cases if they had been involved directly in the care. In some cases team members may have had prior knowledge or were aware of local circumstances related to a specific case and accordingly were encouraged to contribute any relevant further information. All reviewers had previous experience with the described process of case review.

A summary and time line were prepared for each case by a research assistant. In addition, the case notes were reviewed by 2 members of the multidisciplinary team (1 maternity and 1 pediatric), and these reviewers then presented the case to the full panel prior to discussion and then scoring using the checklist tool (Table 1) and

discussion of specific issues or potential recommendations.

Contributory factors were defined as modifiable components of the health system and issues of quality of care covering a broad spectrum of management, personnel, and access/engagement with care that had an impact on the outcome of the case.⁵ Each of these domains includes a checklist of 4–11 items (Table 1). One or multiple categories and subcategories could be selected in any individual case.

Potentially avoidable mortality or morbidity was determined where the absence of any of the contributory factors could have resulted in survival or in less severe morbidity. Potentially avoidable mortality or morbidity was determined following the assessment of contributory factors, and the team decided which contributory factor or factors had led to a case being defined as potentially avoidable.⁵ The team was also asked to identify case-specific issues to inform the development of recommendations to drive quality improvement.

When all of the review meetings were complete, a meeting was held to review the overall findings and to prioritize the issues raised from individual case reviews into thematic areas to develop recommendations or areas for further development.

Data collected by the NEWG at the notification of the cases were made available by the PMMRC for the purposes of this study and were merged with the data from the clinical reviews for further analysis. The univariate analyses were performed using STATA version 9.2 (StataCorp, College Station, TX). The frequencies of the contributory factors were compared using χ^2 tests.

Institutional review board approval for this study was not required because the case reviews were completed under the New Zealand Public Health and Disability Act of 2000 (NZPHD Act). The PMMRC was established under the NZPHD Act, which provides the PMMRC with the power to request information relevant to the committee's functions of reviewing and reporting on morbidity and mortality with a view to reducing both. The NZPHD Act outlines

TABLE 1
Contributory factors among babies with NE associated with perinatal asphyxia by survivorship status, 2010–2011

Factors	NE (n = 83)		Deceased (n = 21)		Survivors (n = 62)	
	%	n/N	%	n/N	%	n/N
Contributory factor	84	70/83	86	18/21	84	52/62
Organization/management factors	37	31/83	33	7/21	39	24/62
Poor organizational arrangements of staff	4	3/83	0	0	5	3/62
Lack of policies, protocols, or guidelines	6	5/83	0	0	8	5/62
Inadequate numbers of staff	5	4/83	5	1/21	5	3/62
Poor access to senior clinical staff	7	6/83	10	2/21	6	4/62
Delay in procedure (eg, cesarean delivery)	10	8/83	5	1/21	11	7/62
Delayed access to test results or inaccurate results	8	7/83	10	2/21	8	5/62
Other	16	13/83	19	4/21	15	9/62
Personnel factors	76	63/83	76	16/21	76	47/62
Knowledge and skills of staff were lacking	34	28/83	43	9/21	31	19/62
Delayed emergency response by staff	27	22/83	24	5/21	27	17/62
Failure to maintain competence	5	4/83	5	1/21	5	3/62
Failure of communication between staff	12	10/83	14	3/21	11	7/62
Failure to seek help/supervision	28	23/83	38	8/21	24	15/62
Failure to offer or follow recommended best practice	58	48/83	57	12/21	58	36/62
Lack of recognition of complexity or seriousness of condition by caregiver	55	46/83	52	11/21	56	35/62
Other	1	1/83	5	1/21	0	0
Barriers to access or engagement with care	24	20/83	24	5/21	24	15/62
Infrequent care or late booking	8	7/83	10	2/21	8	5/62
Declined treatment or advice	4	3/83	5	1/21	3	2/62
Obesity having an impact on delivery of optimal care (eg, USS)	5	4/83	5	1/21	5	3/62
Environment (eg, isolated, long transfer, weather prevented transport)	5	4/83	0	0	6	4/62
Other	8	7/83	10	2/21	8	5/62

NE, neonatal encephalopathy; USS, ultrasound scan.

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the PMMRC's responsibility for ensuring the information provided is kept confidential and all publications are grouped and individuals are not identifiable.

Results

In the years 2010–2011, 149 cases of NE were reported (1.27 per 1000 term births). Of these cases, 96 (64%) were assessed as moderate and 53 (36%) as severe. Thirty-six (24%) babies died before discharge from the hospital.

Descriptive data are available in the PMMRC Annual Reports 2011 and 2012.^{5,6}

Eighty-three babies, 56 (67%) moderate, and 27 (33%) severe fulfilled the inclusion criteria for the review, 21 (25%) of whom were deceased prior to hospital discharge. Excluding 5 babies who died within a day of birth, all but 1 baby were admitted to a neonatal unit within 1 day of birth. One baby was admitted on day 2. Forty-five (54%) had magnetic resonance imaging performed

between day 1 and day 28 of life, and of these 18 (40%) were reported as moderate or severely abnormal and 26 (58%) normal or mildly abnormal. Mode of birth, blood gas results, and Apgar scores at 1, 5, and 10 minutes are shown in [Table 2](#).

Contributory factors were identified in 84% of cases of unexpected NE associated with hypoxia at birth and did not vary by survival status ($P = .8$) ([Table 1](#)). There were personnel factors present in 76% of cases, organization/management

TABLE 2

Clinical features of babies with NE associated with perinatal asphyxia by survivorship status, 2010–2011

Clinical characteristic	NE (n = 83)		Deceased (n = 21)		Survivors (n = 62)	
	%	n/N	%	n/N	%	n/N
Sarnat stage⁷						
Moderate	67	56/83	5	1/21	89	55/62
Severe	33	27/83	95	20/21	11	7/62
Gestation (mean [SD])	39.5 (1.3)		39.3 (1.6)		39.6 (1.2)	
Birthweight (mean [SD])	3412 (520)		3327 (710)		3439 (441)	
Mode of birth						
Cesarean delivery	30	25/83	29	6/21	31	19/62
Normal vaginal delivery	49	41/83	57	12/21	48	29/62
Operative vaginal delivery	18	15/83	14	3/21	19	12/62
Vaginal breech	2	2/83	0		3	2/62
Apgar score						
At 1 min (median [IQR])	2 (1-4)		1 (0-3)		2 (1-4)	
At 5 min (median [IQR])	4 (2-6)		2 (0-4)		4 (3-6)	
At 5 min < 5	58 48/83		76 (16/21)		52 (32/62)	
At 5 min < 7	82 68/83		90 (19/21)		79 (49/62)	
At 10 min < 5	29 (24/83)		67 (14/21)		16 (10/62)	
Cord blood gases (n = 64)						
(any of pH ≤ 7.0, BE ≤ -12, lactate ≥ 6)	84 (54/64)		93 (14/15)		82 (40/49)	

BE, base excess; IQR, interquartile range; NE, neonatal encephalopathy.

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in 37%, and barriers to access or engagement with care in 24% and these proportions did not vary by survival status ($P = .7$, $P = 1.0$, and $P = 1.0$, respectively).

In 28 cases (34%), contributory factors were identified from 2 subcategories and in 8 cases (10%) from all 3 subcategories. Failure to offer or follow recommended best practice and failure to recognize the complexity or seriousness of the condition were the most common personnel factors and were each found in more than 50% of cases. Lack of skills of staff and delay in emergency response were also common, found in 34% and 27% of cases, respectively. No subcategory of organization, management, or barrier to access or engagement with care factors was present in more than 10% of cases reviewed (Table 1).

Fifty-five percent of reviewed cases were assessed as potentially avoidable (Table 3). Overall, 52% of cases were assessed as potentially avoidable because of personnel issues. The rate of potentially avoidable death/morbidity did not vary significantly by whether babies died or survived.

Thirty-six of the 46 potentially avoidable morbidities or mortalities were noted to be associated with a contributory factor relating to fetal surveillance in labor, 31 of these relating to use and interpretation of cardiocographs (CTGs).

Table 4 includes the specific issues identified at case review, grouped by theme and categorized temporally in relation to birth. The key themes identified were risk assessment and management, use of best practice, fetal surveillance, resuscitation, recognition

of neonatal risk, and documentation. Many issues were identified multiple times, and these are described in the paragraphs below.

In 8 cases the review process identified concerns about risk identification and selection of place of birth. In addition, there were instances in which the initial assessment was low risk, but when this changed because of new factors developing (eg, postdates or large for gestational age), there was no documented evidence of a reevaluation of appropriate place of birth.

In 10 cases, risk assessment at the onset of labor indicated a need for increased fetal surveillance, but this did not occur.

A failure to follow recommended best practice was the theme of 21 comments. The most frequent of these related to the failure to undertake appropriate antenatal assessment of fetal growth and recognize small for gestational age (9 comments). Some of the issues identified by the review included cases with no evidence of a fundal height being measured or clinical notes that were limited to a comment that said growth is equal.

Issues with fetal surveillance in labor were identified in 45 comments, 26 of which related to the interpretation and management of CTG in labor and 7 to best practice for intermittent auscultation. There were also comments in 6 cases relating to a failure to provide monitoring of the water temperature during use of water baths in labor.

The case review documented 10 cases with issues that related to inadequate neonatal resuscitation (as assessed by the multidisciplinary team) and 23 comments around failure to recognize potential neurological compromise and/or identifying the potential for benefit from induced cooling. There were several examples in which abnormal fetal/neonatal status was either missed by the team providing care or normalized. This included late or no recognition of fetal distress, resulting in delay in notification to pediatric teams to attend the delivery.

After birth, issues identified by the case review included poor handover of details regarding fetal status, late

recognition of neonatal neurological problems (especially when there were significant signs in another system such as the respiratory system), and delays in senior pediatric review of babies who were stable from a cardiorespiratory perspective after resuscitation but potentially eligible for cooling.

There were a number of times when documentation was noted to be suboptimal. The issue of poor documentation of risk assessment and CTG interpretation and management were included among these comments. In addition, CTG records were not available in 4 of the 44 cases reviewed in which they were requested (9%). There were also concerns regarding the availability of clinical notes during later episodes of care such as cases in which poor documentation of maternal group B streptococcus urine infection resulted in missed antibiotic prophylaxis in labor.

Comment

This multidisciplinary clinical case review of 83 babies with NE without an acute peripartum event identified contributory factors in 84% of cases and found the severity of the outcome was potentially avoidable in 55% of cases. Personnel factors contributed in 76% of cases and were the main contributory factor to a potentially avoidable outcome in 52% of cases. Organization and/or management factors and barriers to access and/or engagement with care were the main contributors to potentially avoidable outcome in only 2% and 6% of cases, respectively.

The focus of the current review was on intrapartum care in which there was no identified acute event. In addition to potentially avoidable morbidity or mortality in 55% of cases, contributory factors were identified in a further 29% of cases. These findings did not vary by survival status. The experience is similar to that reported for Trent region, United Kingdom, in which 64% of NE cases and 75% of deaths had significant or major episodes of suboptimal care identified in pregnancy, during labor, or after delivery.² Pattinson¹⁰ from South Africa reported deaths caused by intrapartum asphyxia and birth trauma, which were

TABLE 3
Potentially avoidable morbidity and main contributory factor(s) among babies with NE associated with perinatal asphyxia by survivorship status, 2010–2011

Potentially avoidable morbidity/mortality?	NE cases (n = 83)		Deceased (n = 21)		Survivors (n = 62)	
	%	n/N	%	n/N	%	n/N
Total	55	46/83	62	13/21	53	33/62
Main factor(s) ^a						
Organization/management	6	5/83	—	—	8	5/62
Personnel	52	43/83	62	13/21	48	30/62
Barriers	2	2/83	—	—	3	2/62

NE, neonatal encephalopathy.

^a May not be mutually exclusive.

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thought to be preventable in 63.1%, 34.4%, and 35.7% of cases in the metropolitan areas, cities and towns, and rural areas, respectively. Jonsson et al³ reported suboptimal care in 36% of NE cases in Sweden.

The findings strongly suggest that improvement in the quality of intrapartum care could significantly either decrease outcome severity or prevent a proportion of the cases of NE. Similar findings were reported from an analysis of asphyxia in a single center in Scotland, which subsequently demonstrated a substantial and steady fall in the rate of asphyxia over a 12 year period, suggesting that a significant proportion may be preventable.¹¹ Further support for potential avoidability comes from confidential enquiries in various countries.^{1–3,12} It is also consistent with the finding that greater than 50% of the hypoxic peripartum deaths in New Zealand were potentially avoidable, with the most common contributory factor being personnel issues.^{5,6}

Other studies have reported reductions in asphyxial injury after addressing concerns about intrapartum care. Draycott et al¹³ reported a 50% reduction in Apgar scores < 7 at 5 minutes and in hypoxic ischemic encephalopathy (HIE) rates following the introduction of mandatory hospital-supported annual multidisciplinary obstetric emergency training including a

half-day of CTG education. The reduction in asphyxial morbidity and mortality reported by Becher et al¹¹ in 2007 was associated temporally with the introduction of universal CTG training, increased attention to risk assessment, and an increase in specialist obstetric involvement in labor care.

In the domain of personnel as a contributory factor, failure to offer or follow the recommended best practice and failure to recognize the complexity or seriousness of the condition were the most common issues identified, occurring in greater than half of the cases. A lack of staff skill and delay in emergency response were also common, found in 34% and 27% of the cases, respectively. Similar findings have been reported by others. Intrapartum professional factors were reported in 53% of NE cases from Trent (United Kingdom), with delays in communication (41%) and failure to recognize abnormal CTG or meconium (25%) being the most common.² In an audit from South Africa, the most frequent category of probable avoidable factors was related to health workers with inadequate fetal monitoring being the most common.¹ Jonsson et al³ reported no or inappropriate response to a pathological CTG and the injudicious use of oxytocin in association with a pathological CTG as the most frequent reasons for suboptimal care.

TABLE 4
Issues identified at case review

Time	Theme	Issues	Cases (n = 83), n
Prelabor	Risk assessment	Importance of initial and repeated risk assessment around place of birth along with a culture that enables ease of transfer of place of birth/care when appropriate	8
		Risk (and compounding risks) recognized prior to labor indicate a need for increased fetal surveillance in labor; tendency to normalize rather than acting on risk factors; includes women being induced	10
	Best practice	Adherence to referral guidelines, including clarity around clinical responsibility for women during induction of labor	3
		Issues around following recommended best practice:	
		Fetal growth	9
		Hypertension	1
		Assessment of postdates pregnancy	3
		Group B streptococcus guidelines	2
	Other	Raised BMI	3
		Effective policies for women who miss appointments	1
		Education for women concerning importance of ruptured membranes and the importance of antenatal care	2
		Test results need to be followed up by person ordering the test	1
		Thorough assessment of women with pain in pregnancy	1
Labor	Fetal/maternal surveillance	Need for education concerning interpretation of CTGs, and need for a plan to follow interpretation of the CTG	22
		Escalation of management with abnormal CTG (eg, fetal blood sampling, specialist review)	4
		Training in appropriate way to undertake intermittent auscultation	7
		Maternal observations in labor: need for adherence to a standard protocol	4
		Obesity having impact on ability to monitor fetal well-being	2
		Temperature of water bath: standards not followed	6
	Other	Need for flexible staffing in high-acuity situations; core staff to support LMCs as required	3
		Need to maintain ideal timelines for emergency cesarean delivery	1
		Specialist support of trainees for example second-stage cesarean delivery, twins	2
		Codeine is not a drug of choice in labor	3

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(continued)

Optimal maternal and fetal surveillance involves incorporating known prior risk with dynamic assessment to guide the choice of the appropriate method of surveillance and revising this in response to any alteration in risk during labor. Improved outcomes of care have been reported to result from a program of improving standards of intrapartum fetal monitoring, even though the use of CTG in labor is known to be limited by the poor specificity of the test.¹³⁻¹⁵ The New Zealand College of Midwives and the Royal Australasian

College of Obstetricians and Gynecologists endorsed a guideline for fetal surveillance in labor in 2014.¹⁶ Implementation of this guideline with a requirement for regular multidisciplinary training in CTG interpretation for all maternity caregivers may be useful.

Cross-disciplinary issues related to neonatal resuscitation training were noted in 10 cases in this review (12%). There were also issues with appropriate referral and timing of request for pediatric support at delivery. Reports of

delayed or inappropriate resuscitation range from less than 1% to 25% in previous reports.^{1,2} The review of Velaphi and Pattinson¹ of neonatal deaths from HIE noted that the low rate was likely the result of poor observation of resuscitation, poor record taking, and lack of neonatal involvement in death review.

It is widely recognized that neonatal resuscitation training should be provided for all staff involved in maternity care. At the very least, all clinicians caring for birthing women should be proficient at initiating basic neonatal resuscitation

TABLE 4
Issues identified at case review (continued)

Time	Theme	Issues	Cases (n = 83), n
Postnatal/ pediatrics	Recognition	Recognition/full assessment of neonate, including neurological system when respiratory problems presenting, especially if history of labor hypoxia not conveyed or recognized	3
		Observation of newborn: if cardiac compressions are required for resuscitation, then consultant pediatrician should review neurological status of newborn early (in first hour)	1
		Clear guidelines required for indications for transfer of a baby from home/birthing unit/primary unit to level 2/3 care and from level 2 to level 3; early discussion between level 2 and level 3 clinicians around the potential for cooling	9
		Active observation of the newborn: education required concerning identification of babies who have not made an adequate transition	3
		Delay in notification of pediatrician to attend birth: need for a guide as to when pediatric assistance should be requested (eg, delay in delivery, fetal distress)	6
		Education for neonatal nurses in level 2 units concerning care of asphyxiated baby	1
	Resuscitation	Neonatal resuscitation training for all staff involved in obstetrics	8
		Ensure all resuscitation equipment is in working order at all times	1
		Should “consider need for blood replacement” be on resuscitation chart for pediatrics?	1
	Other	Cord gas (or early neonatal gas if cord gas unsuccessful) should be performed if Apgar score at 5 min < 7	2
		Babies born in water require early temperature	1
		Documentation of neurological examinations including aEEGs	5
		Placental histology may be useful and should be requested for HIE babies	2
	Documentation	Thorough and appropriate documentation, including update of plans to mitigate recognized risks	7
		A copy of the LMC notes should remain as part of the woman’s birthing unit record	4
CTGs should be retained as important clinical records		4	
Other	Other	Support local review of cases of intrapartum morbidity/HIE	3

aEEG, amplitude-integrated electroencephalogram; BMI, body mass index; CTG, cardiotocograph; HIE, hypoxic ischemic encephalopathy; LMC, lead maternity carer. Sadler et al. Neonatal encephalopathy with perinatal asphyxia. *Am J Obstet Gynecol* 2016.

until more specialized support is available. Those caring for newborns need to consider the possibility of brain injury in the compromised newborn, to be able to recognize early a baby that would potentially benefit from induced cooling treatment, and to initiate safe provision of passive cooling, pending transfer of care to the pediatric team.

In acknowledgement of consumer autonomy arising from individually negotiated care based on informed choice and consent, improved documentation around decision making, (including information provided, options offered, recommendations, and decisions reached), in relation to risk assessment and management would make the review of cases and discussion

of contributory factors and potentially avoidable outcomes more accurate.

The strengths of this study include the ascertainment of cases by active national surveillance and access to clinical notes. The study was performed under the PMMRC and so was facilitated by the legislation that supports that group and the relationships the group has within the maternity and pediatric community. Another strength was that it involved multidisciplinary review using a recognized tool for clinical review. As with other confidential inquiries, there was a no-blame systems approach and the clinician caring for the index cases was not involved in the case reviews. However, if team members were familiar with local circumstances such as geography or

local practice or if they could contribute other additional local knowledge, this was encouraged.

The goal was to review babies with neonatal encephalopathy likely to have had an acute hypoxic event peripartum, as defined by the neonatal encephalopathy and neurological outcome monograph definition, while excluding those in which there was a clear sentinel hypoxia-inducing event.⁴ Difficulty defining these babies, because not all NE babies in the cohort had cord gases taken, and Apgar scores are known to be unreliable was a limitation of this study.

A further limitation of the study was that the review methodology was retrospective and undertaken at a

distance from the units in which cases occurred and was limited by the documentation of events available. Although the current study methodology was an independent national review, the NEWG recommends ongoing local review as a sustainable lower cost alternative to identify issues with relevant local context, to assist local multidisciplinary learning, and inform local quality improvement.

The retrospective analysis of CTGs is also a limitation of this study. Ayres-de-Campos et al¹⁷ demonstrated that knowledge of low umbilical pH led to a significant increase in the identification of abnormal CTG features compared with a review without knowledge of pH. Furthermore, the utility of CTG in the prediction of NE has been questioned.¹⁸

Although the model of midwifery and obstetric care in the United States differs from that in New Zealand, there remains complex interplay between the professions, with stresses placed on them by the work and by their patients because of the constant 24 hour nature of their work. Review of NE cases, which it would seem still occur in both countries, will lead to the identification of those issues that predominate in each environment. The study described here provides a robust model for rapid multidisciplinary systems-based approach to the review of hypoxic ischemic cases. This approach may be timelier than that of root cause analysis as suggested in the American College of Obstetricians and Gynecologists monologue.⁴

In summary, these case reviews identified a high proportion of contributory factors and significant morbidity that was potentially avoidable, consistent with previous published reviews of NE. Personnel were the most common contributory factors, and well-considered and broadly implemented initiatives to address these in New Zealand have the potential to reduce the rate of, and morbidity from, NE. ■

Acknowledgments

Members of the Neonatal Encephalopathy Working Group of the New Zealand Perinatal and Maternal Mortality Review Committee

include the following: Dr Astrid Budden, Ms Anja Hale, Dr Deborah Harris, Ms Gail McIver, Ms Suzanne Miller, Dr Thorsten Stanley, Ms Rachel Taylor, and Dr Alex Wallace. Individuals who assisted with the preparation of cases and with the reviews include the following: Dr Sarah Armstrong, Dr Kitty Bach, Dr Lynda Batcheler, Dr Rose Elder, Dr Al Haslam, Dr Sarah Wadsworth, and Dr Claire West. We thank the New Zealand Paediatric Surveillance Unit for their assistance with case ascertainment. We also thank the clinicians who submitted their cases to the database.

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Received Oct. 5, 2015; revised Dec. 9, 2015; accepted Dec. 17, 2015.

The Accident Compensation and the Health Quality and Safety Commissions of New Zealand had no role in study design; in the collection, analysis, and interpretation of data; in the writing of the report; or in the decision to submit the article for publication.

This study was supported by the Accident Compensation and the Health Quality and Safety Commissions of New Zealand.

The authors report no conflict of interest.

A summary of the findings of this study was presented as a poster presentation at the Royal College of Obstetricians and Gynaecologists/Royal Australian and New Zealand College of Obstetricians and Gynaecologists World Congress 2015, Brisbane, Australia, April 12-15, 2015, and at the Perinatal and Maternal Mortality Review Committee Conference, June 17, 2015, Wellington, New Zealand.

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