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Original Article

Screening for feeding difficulties in the neonatal unit: Sensitivity and specificity of gestational age vs. medical history

Sarah K. Edney[a,*], Stephanie Jones[b], Elizabeth Boaden[b]

[a] Lancashire Teaching Hospitals NHS Foundation Trust, United Kingdom
[b] University of Central Lancashire, United Kingdom

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ABSTRACT

Background: Studies to inform feeding interventions on neonatal units are lacking. This study aims to compare gestational age and medical history as methods of identifying infants at higher risk of developing feeding difficulties by 40 weeks gestational age.
Method: A retrospective case note analysis was conducted on a level 3 neonatal unit. Infants were given a severity category based on gestational age at birth and medical history. Feeding outcomes were analysed for sensitivity, specificity, and positive and negative predictive values.
Results: 233 infants were included. Medical history at severity level 2 provided a high level of sensitivity (84.62%) and specificity (87.92%) for feeding difficulties at 40 weeks gestational age.
Conclusion: Medical history can be used as a simple method to identify infants at highest risk of feeding difficulties prior to commencing oral feeding, enabling the targeting of preventative therapeutic interventions and caseload prioritisation.

1. Introduction

Feeding difficulties are common in neonatal populations (Hawdon et al., 2000; Lee et al., 2011) with the type and severity of difficulties ranging from mildly delayed transition from tube to oral feeding to significant swallowing problems with aspiration. These difficulties often continue after discharge from the neonatal setting. Recent research has reported that infants born before 30 weeks were more than twice as likely to have feeding difficulties at 12 months corrected age than healthy term-born children (OR 2.21, 95% CI 1.55–3.16 (Sanchez et al., 2017). A further study found that 20.4% of 1–2 year old children previously admitted to a neonatal unit experienced feeding difficulties, whereas this occurred in only 15% of a healthy term-born reference population (Hoogewerf et al., 2017).

In the United Kingdom, Speech and Language Therapists work with infants who have or are at risk of developing significant feeding problems to prevent or reduce the impact of these difficulties. While all vulnerable infants require feeding in response to their cues and abilities and monitoring by experienced neonatal staff, including Speech and Language Therapists, some require more intensive specialist input. In order to best target pre-feeding interventions and to monitor feeding progression and safety, these professionals require data on which infants are at highest risk of feeding difficulties. High-risk infants can then receive additional support in undergoing neonatal feeding interventions such as oral stimulation and non-nutritive sucking in an attempt to prevent or reduce feeding problems (Foster et al., 2016; Greene et al., 2012).

Due to limited studies and differing definitions, the overall incidence of feeding difficulties in neonatal units is unclear but ranges from 26% (Lee et al., 2011) to 40% (Hawdon et al., 2000). Certain patient groups appear to be particularly at risk of feeding difficulties and delays. Babies born at 32 weeks gestational age are slower to achieve full oral feeding than those born at 36 weeks (Jackson et al., 2016) and low birth weight is associated with older age at achievement of full oral feeding (Giannì et al., 2015). Impaired respiratory function, gastrointestinal complications, neurological involvement, and cardiac defects have all been associated with delayed feeding progression and poor feeding outcomes in preterm infants (Giannì et al., 2015; Jadcherla et al., 2010; Park et al., 2015). It is also important to note that not all infants with feeding difficulties on a neonatal unit are premature. Children who undergo cardiac surgery (Ricci et al., 2016) and gastrointestinal surgery (Huynh-Trudeau et al., 2015) in the neonatal period often experience significant feeding difficulties and require long term tube feeding. Infants with neurological impairment also frequently experience feeding difficulties (Salemi et al., 2014), as do those with congenital abnormalities of the aerodigestive tract, such as those

* Corresponding author. Speech and Language Therapy, Royal Preston Hospital, Sharoe Green Lane, Fulwood, Preston, PR2 9HT, United Kingdom.
E-mail address: sarah.edney@lthtr.nhs.uk (S.K. Edney).

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found in Pierre Robin sequence (Daniel et al., 2013).

When seeking to identify infants at highest risk of feeding difficulties, the current neonatal feeding literature is lacking in three ways. First, the feeding outcomes reported during the neonatal admission period often do not represent the most clinically significant feeding issues. For example, a commonly used outcome is days to full oral feeding (Jackson et al., 2016). Some babies will progress to full oral feeding more slowly than others, but this does not always facilitate the identification of infants with potentially unsafe swallowing or other infants who are in most need of specialist assessment and interventions. Second, most studies focus on preterms (Giannì et al., 2015) and neonatal sub-populations (Joseph et al., 2017) rather than the neonatal population as a whole. This results in inadequate data on the prevalence of feeding difficulties in neonatal settings and little to no data on groups that have not been targeted by researchers. Finally, the babies at highest risk of feeding difficulties, such as those with conditions including congenital anomalies, chronic lung disease, and positive finding on head scan are often excluded from research studies when investigating oral feeding in preterms (Hwang et al., 2013; Park et al., 2015; White-Traut et al., 2013). While these studies provide valuable information on the effect of prematurity on feeding, they often result in inadequate data about those infants who are most likely to have feeding difficulties.

Few studies have reported on a neonatal population as a whole. Hawdon et al. (2000) used the Neonatal Oral Motor Assessment Scale (Palmer et al., 1993) to assess 35 infants on a neonatal unit at 36–40 weeks post-menstrual age, including term and preterm infants but excluding infants with short admissions. Of the 35 infants, 12 (34%) were assessed as having disorganised feeding and 2 (6%) as having dysfunctional feeding, with neurological and respiratory disorders being common among these infants. Lee et al. (2011) studied 142 infants on a neonatal unit at > 36 weeks post-menstrual age, including term and preterm infants, to identify those with feeding difficulties affecting swallow safety. Thirty-seven infants (26%) showed clinical signs of swallowing difficulties. Of these, 22 (16%) showed signs of swallowing difficulties on videofluoroscopy. These findings demonstrate that the incidence of dysphagia is high among neonatal populations and that clinical signs of dysphagia should be investigated. In this study there was no significant correlation between gestational age at birth and abnormal videofluoroscopy findings. This suggests that the exclusion of term babies and subpopulations from studies of neonatal feeding may be resulting in a disproportionate emphasis on prematurity in the neonatal feeding literature.

This study aims to compare medical history with gestational age at birth in order to determine which is better at identifying infants at high risk of developing feeding difficulties while on the neonatal unit.

2. Methods

2.1. Design

Retrospective case note analysis.

2.2. Setting

A Level 3 Neonatal Unit (including intensive care, high dependency, and special care) in an acute hospital in north-west England.

2.3. Sample

Data were collected for all infants admitted to the neonatal unit from 1st January 2015 to 30th June 2015.

2.4. Data collection

Routinely collected data was taken from a patient data management system, which is updated daily for all babies in neonatal units in the United Kingdom. It includes admission summaries, discharge reports, daily procedures, and feeding methods. Data collected for each infant included categories for gestational age group at birth, medical history based on number of medical problems, and feeding outcome.

2.4.1. Gestational age

Gestational age groups were based on the categories used by the World Health Organisation: term (> 37 weeks), moderate to late preterm (32–36 + 6 weeks); very preterm, (28–31 + 6 weeks); or extremely preterm (< 28 weeks) (Quinn et al., 2016). These groups were allocated a severity score of 0–3, with 0 representing term and 3 representing extremely preterm.

2.4.2. Medical history

Medical history was categorised by the number of impaired body systems from the following list: neurological, respiratory, gastrointestinal, cardiac, and craniofacial. Following a scoping review of the literature, it was determined that these five systems are the most commonly related to feeding difficulties. The presence or absence of involvement of these systems was determined by the infant's discharge letter. If a problem was listed under any of these system headings, it was recorded as positive, regardless of severity or duration. As not all conditions within these body systems are associated with sustained feeding difficulties, the following conditions were not included: retinopathy of prematurity, transient tachypnea of the newborn, intraventricular haemorrhage grades 1–2, and brachial plexus injury with no respiratory compromise. Infants were categorised as having none, one, two, or three or more impaired body systems, giving a severity score of 0–3, with 0 representing no impairments to these body systems and 3 representing impairment to 3 or more of these body systems.

2.4.3. Feeding outcome

Feeding outcome categories included the presence or absence of a feeding difficulty, with a sub-category for tube feeding at discharge. At the time of data collection, this unit did not utilise tube feeding as a means of supporting early discharge and tube feeding at discharge was only associated with ongoing feeding difficulty. A feeding difficulty is defined as inability to achieve full oral feeding by: 40 weeks post-menstrual age (due date); discharge home if < 40 weeks; or one-week chronological age if born at or over 39 weeks. This definition was determined following consultation with the neonatal team during which it was agreed that ongoing tube feeding at 40 weeks represented a clinically significant feeding difficulty.

2.5. Analysis

Feeding outcomes based on gestational age at birth and medical history were compared at three levels of severity: any degree of prematurity vs. one or more systems impaired; very preterm or earlier vs. two or more systems impaired; and extremely preterm vs. three or more systems impaired. Sensitivity, specificity, positive predictive values, negative predictive values, including 95% confidence intervals, were calculated for gestational age at birth and medical history at each level of severity. Sensitivity and specificity figures for the three degrees of severity for both gestational age and medical history were plotted on a Receiver Operating Characteristic curve to determine which was most accurate in identifying infants who would go on to have feeding difficulties at 40 weeks.

2.6. Ethical considerations

The study design and procedures were approved by East Midlands - Nottingham 2 Research Ethics Committee (Approval number: 16/EM/0328). Parent/guardian consent was not sought for reasons of practicality. Data was collected retrospectively and anonymously in a coded

Table 1
Feeding outcomes by gestational age.

Gestational age category	Oral feeding by 40 weeks n (%)	Feeding difficulty at 40 weeks n (%)	Feeding difficulty and tube feeding at discharge n (%)	TOTAL n (%)
Extremely Preterm	11 (55)	9 (45)	2 (10)	20 (9)
Very Preterm	21 (84)	4 (16)	0 (0)	25 (11)
Mod-Late Preterm	71 (95)	4 (5)	3 (4)	75 (32)
Term	104 (92)	9 (8)	3 (3)	113 (48)
TOTAL	207 (89)	26 (11)	8 (3)	233 (100)

format by a member of the clinical team with written permission from the institution's Neonatal Clinical Director.

3. Results

3.1. Sample

Feeding outcome data was missing for 17 infants, resulting in a total sample size of 233. The sample included 113 term infants (48%), 75 moderate-late preterm infants (32%), 25 very preterm infants (11%), and 20 extremely preterm infants (9%). 96 of the 233 infants (41%) had no impairments to any of the identified body systems. 90 (39%) had one system impaired, 33 (14%) had two systems impaired, and 14 infants (6%) had three or more of the identified body systems impaired.

3.2. Feeding outcomes

As can be seen in Tables 1 and 2, feeding difficulties were more prevalent among the most preterm infants and the infants with the largest number of impaired body systems. Of the total sample, 26 (11%) infants had feeding difficulties at 40 weeks gestational age. Furthermore, 8 infants (3%) were unable to achieve full oral feeding during their admission and were discharged with tube feeding.

3.3. Comparison of screening methods

Looking at severity level one, identifying infants with a medical history including impairment to one or more of the targeted body systems was more sensitive to feeding difficulties at 40 weeks gestational age than identifying those with any degree of prematurity. Positive and negative predictive values were also stronger. However, any degree of prematurity had stronger specificity than medical history at this level. At severity levels two and three, a medical history of impairment to two or more of these body systems was a consistently stronger indicator of feeding difficulties at 40 weeks when compared to gestational age at birth of below 32 weeks (see Tables 3–5). Fig. 1 demonstrates that utilising medical history at severity level 2 provides a high level of both sensitivity (84.62%, 95% CI = 65.13%–95.64%) and specificity (87.92%, 95% CI = 82.69%–92.03%) for clinically significant feeding difficulties.

Table 2
Feeding Outcomes by Medical History: Number of Systems Impaired.

Systems involved	Oral feeding by 40 weeks n (%)	Feeding difficulty at 40 weeks n (%)	Feeding difficulty and tube feeding at discharge n (%)	TOTAL n (%)
3	4 (29)	10 (71)	6 (43)	14 (6)
2	21 (64)	12 (36)	2 (6)	33 (14)
1	89 (99)	1 (1)	0 (0)	90 (39)
0	93 (97)	3 (3)	0 (0)	96 (41)
TOTAL	207 (89)	26 (11)	8 (3)	233 (100)

Table 3
Severity level 1 - Any degree of prematurity vs. one or more systems impaired.

	Gestational age (%) (95% CI)	Medical history (%) (95% CI)
Sensitivity	65.38 (44.33–82.79)	**88.46** (69.85–97.55)
Specificity	**50.24** (43.23–57.25)	44.93 (38.03–51.98)
PPV	14.17 (10.78–18.39)	**16.79** (14.35–19.54)
NPV	92.04 (87.01–95.22)	**96.88** (91.36–98.91)

Table 4
Severity level 2 – Very preterm or earlier vs. two or more systems impaired.

	Gestational age (%) (95% CI)	Medical history (%) (95% CI)
Sensitivity	50 (29.93–70.07)	**84.62** (65.13–95.64)
Specificity	84.54 (78.88–89.18)	**87.92** (82.69–92.03)
PPV	28.89 (19.78–40.09)	**46.81** (37.04–56.82)
NPV	93.09 (90.12–95.21)	**97.85** (94.86–99.12)

Table 5
Severity level 3 – Extremely preterm vs. three or more systems impaired.

	Gestational age (%) (95% CI)	Medical history (%) (95% CI)
Sensitivity	34.62 (17.21–55.67)	**38.46** (20.23–59.43)
Specificity	94.69 (90.69–97.32)	**98.07** (95.13–99.47)
PPV	45 (27.26–64.11)	**71.43** (45.78–88.10)
NPV	92.02 (89.69–93.86)	**92.69** (90.34–94.51)

4. Discussion

This study demonstrates that medical history can be used to identify infants on a neonatal unit who are at highest risk of feeding difficulties at 40 weeks gestational age. While gestational age at birth is relevant to feeding outcomes, it is a comparatively poor method for identifying infants in most need of specialist feeding assessment and interventions in terms of sensitivity, specificity, positive predictive value, and negative predictive value.

The study presented here has several limitations. The use of retrospective, routinely collected patient data relies on accurate documentation in everyday clinical practice. However, the broad categories used to classify medical history may negate this concern. While the body systems used to categorise medical history were based on current knowledge of feeding outcomes and associated co-morbidities among neonates, it is possible that other clinically important factors were not considered, such as infections unrelated to these systems. The need for simplicity, both within the study design and for clinical application of the screening method, prevented utilising severity of conditions in the categorisation of medical history. The sample size used in this study was relatively small. It is not certain that the outcome used, full oral feeding by 40 weeks gestational age (or within a week of birth for term infants), is associated with the feeding problems that often occur in neonatal unit graduates in later infancy and childhood. Finally, it has not been determined what parents consider to be a clinically important marker of feeding progression or what feeding outcomes are most important to them.

Despite these limitations, the data presented is consistent with other studies of feeding outcomes among whole neonatal populations in suggesting that feeding difficulties are common in the neonatal setting and that medical history is a more important factor in an infant's feeding progression than gestational age at birth (Hawdon et al., 2000; Hoogewerf et al., 2017; Lee et al., 2011). Feeding difficulties occurred in 11% of this sample. This is a smaller proportion than reported in other studies (26%–40%) (Hawdon et al., 2000; Lee et al., 2011) which use different criteria to guide the classification of feeding difficulties. This highlights the lack of consensus regarding terminology in the feeding difficulty literature, making comparisons between studies

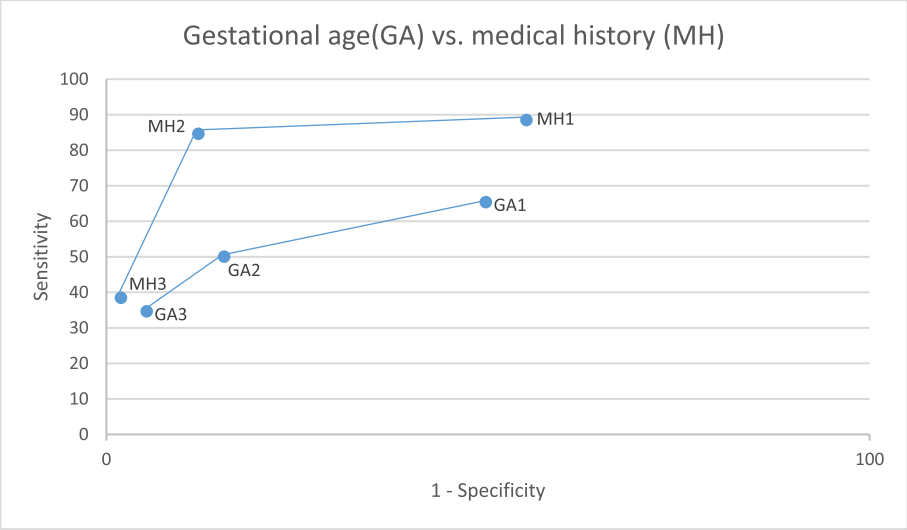

Fig. 1. Receiver Operating Characteristic curve – Gestational age vs. medical history at three levels of severity.
GA1 = Gestational age, severity level 1, GA2 = Gestational age, severity level 2, GA3 = Gestational age, severity level 3.
MH1 = Medical history, severity level 1, MH2 = Medical history, severity level 2, MH3 = Medical history, severity level 3.

difficult. In a previous study, only 9 (24%) of 37 infants with clinical signs of dysphagia had no medical issues beyond prematurity, and there was no significant correlation between abnormal swallowing on videofluoroscopy and gestational age at birth (Lee et al., 2011). Furthermore, Hoogewerf et al. (2017) found that the prevalence of feeding problems among 1–2 year old neonatal intensive care graduates was similar across all gestational age groups. These findings support the notion that the exclusion of unwell term infants and preterm infants with comorbidities from neonatal feeding studies results in a disproportionate emphasis on prematurity in the literature. This is an important consideration for practitioners providing feeding therapy services and for those providing prognostic information to families.

The presence of two or more areas of impairment in the specified body systems was most indicative of infants with poorer feeding outcomes including ongoing tube feeding at 40 weeks. Early identification and prioritisation of high-risk infants allows for targeted feeding skills assessments and interventions to be undertaken prior to the initiation of oral feeding and prior to feeding difficulties developing. Medical history can be used to inform clinical decision-making in utilising resources to prioritise the infants who may benefit most from targeted assessments and interventions, may inform funding requirements for neonatal feeding services, and improve information provision for families.

To further develop our knowledge in the area of feeding outcomes in whole neonatal populations, future studies should focus on robust collection of prospective longitudinal data to determine how well screening methods reflect longer term outcomes, identify outcomes that are meaningful to families, and improve identification and classification of medical factors relevant to feeding outcomes. Mixed methods studies would be particularly valuable in this area, as determining successful and positive infant feeding outcomes is a highly complex and nuanced area, involving nutritional, communication, psycho-social, and quality of life factors.

5. Conclusion

This study demonstrates that medical history can be utilised to identify infants on a neonatal unit who are at highest risk of feeding difficulties prior to the commencement of oral feeding. This enables clinicians to prioritise and target the highest risk infants for assessment and preventative therapeutic interventions.

Conflicts of interest

The authors declare that there is no conflict of interest in publishing this paper.

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The study design and procedures were approved by East Midlands - Nottingham 2 Research Ethics Committee (Approval number: 16/EM/0328).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jnn.2018.10.004.

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