


REGULAR ARTICLE

Full oral feeding is possible before discharge even in extremely preterm infants

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ABSTRACT

Aim: This study described the steps needed to achieve full oral feeding before discharge in a group of very and extremely preterm (EPT) infants. We analysed the effects of oral feeding skills on discharge timing and on weight gain during their neonatal intensive care unit (NICU) stay.

Methods: A prospective cross-sectional observational study of 100 infants who were <32 weeks of gestation (GA) was conducted at the Division of Neonatology, Graz, Austria, from March 2014 to February 2015. Patients were stratified into two groups: those who were <28 weeks at birth and those who were 28 weeks and over. Velocity of oral feeding skills attainment and weight gain were analysed.

Results: All infants successfully acquired oral feeding skills during hospitalisation. The median GA at which full oral feeding skills were reached was 37 + 1 weeks in EPT and 34 + 5 weeks in very preterm infants. More immature neonates showed worse feeding performances and lower weight increments during oral feeding steps.

Conclusion: Our study confirmed the role of GA in the development of oral feeding skills in the most premature babies. It also raises the question of whether expected daily weight gain should be targeted according to GA.

INTRODUCTION

Achieving full oral feeding skills can be particularly challenging for preterm babies, especially those who are born at an extremely low gestational age (GA) and are affected by other comorbidities. This is because they can experience difficulties in coordinating sucking, breathing and swallowing (1). Such difficulties have frequently been associated with growth retardation and adverse neurodevelopmental outcomes later in life, as well as contributing to hospital discharge delay (2).

That is why it is not unusual for these infants to need a certain time with feeding tube before they attain independent oral nutrition.

The American Academy of Pediatrics recommends competent oral feeding by breast or bottle, without cardiorespiratory compromise, should be established before high-risk neonates are discharged (3). However, there has been a

paucity of data regarding the timing of attaining oral feeding skills in preterm infants (4).

Several factors must be considered before initiating oral nutrition and detecting when a premature baby is ready to feed is still a big challenge. The consequences of starting oral feeding at the wrong time can include inadequate fluid management, behavioural distress, an unstable heart rate, hypoxia during feeding, increased energy expenditure and poor weight gain. That is why it is extremely important to

Key notes

- This cross-sectional study analysed the effects of oral feeding skills on the discharge timing and weight gain of 71 infants who were born at <32 weeks.
- All infants successfully acquired oral feeding skills during hospitalisation, at a median gestational age of 37 + 1 weeks for extremely preterm and 34 + 5 weeks for very preterm infants.
- More immature neonates showed worse feeding performances and lower weight increments during oral feeding steps.

Abbreviations

EPT, Extremely preterm; FEN, Full enteral nutrition; GA, Gestational age; NICU, Neonatal intensive care unit; VPT, Very preterm.

assess feeding performance and provide support to help the baby develop sucking skills, in order to achieve successful oral feeding. Although there is a need for further well-designed trials, current studies suggest that oral stimulation shortens hospital stay, days to exclusive oral feeding and the duration of parenteral nutrition (5–7).

Gennattasio et al. (8) proposed different stages of oral feeding initiation and advancement pathways. The first step, which is the ability to suck, depends on GA, neurodevelopmental maturity, behavioural state organisation and also the neonatal intensive care unit (NICU) environment (9). For example, the developmental step of suck–swallow coordination has been positively associated with advancing postmenstrual age (10).

There has been convincing evidence that facilitating cue-based oral feeding, which is the ability to recognise if a baby is ready for feeding and if they show signs of distress during feeding, enhance the development of the infant's ability to feed safely and effectively. Moreover, as reported by Gianni et al., starting both Kangaroo mother care and early parental involvement in the infants' feeding at an early stage positively influenced their ability to achieve independent oral feeding skills.

Given this background, the aim of this study was to observe the differences between how long it took extremely preterm (EPT) infants and very preterm (VPT) infants to achieve full oral feeding using our unit protocol. In addition, we investigated the effects of the transition from tube feeding to oral feeding on growth velocity.

METHODS

A prospective cross-sectional study was conducted in the NICU at the Medical University, Graz Austria from March 2014 to February 2015. All consecutive preterm infants who were <32 weeks of GA when they were admitted to our NICU were screened for eligibility. Infants born with major anomalies and congenital malformations and those needed abdominal surgery were excluded from the study.

The study protocol was approved by the Ethics Committee of the Medical University of Graz. Parental informed consent was obtained prior to enrolment.

Infants were stratified into two groups according to their GA: EPT infants who were born at <28 weeks and VPT infants who were born at 28 weeks or more. Feeding performances and growth velocity were strictly monitored during their hospital stay, from birth until discharge. The feeding protocol has previously been discussed in detail by Khan et al. (11).

Individual feeding performances were assessed at different time points during the tube feeding phase and the oral feeding phase. Tube feeding was started on the first day of life and the tube feeding phase lasted until the baby reached full enteral nutrition (FEN). Weight gain was expressed as daily weight gain (g/kg/day) (12). The oral feeding phase was divided into four subphases: 10, 50 or 100% of daily intake given orally, and *ad libitum* feeding.

Feeding skills evaluation and support

Our unit protocol included prefeeding oral stimulation using a swab stick with the mother's milk, while the baby was on respiratory support. When the infant was weaned from mechanical ventilation, prefeeding oral stimulation (non-nutritive sucking) was started and Kangaroo mother care was promoted. During this phase, the infant's progress to full oral feeding was regularly assessed by the nurses in charge, following a standardised checklist about achievements in accordance with the literature (8,13,14). A stepwise increase in oral feeding intake was then initiated. Once the infant had achieved full oral intake, *ad libitum* feeding was started before discharge.

Data acquisition

Daily parenteral and enteral intake was routinely recorded in the nutrition monitoring system Centricity Electronic Medical Record, (GE Healthcare, Chicago, IL, USA) at the infant's bedside and their weight was monitored during their whole hospital stay.

Statistical analysis

Medians and interquartile ranges were calculated to describe the study population. Significant differences between the groups were analysed using the *t*-test or Mann–Whitney *U*-Test, as appropriate. Statistical analysis was performed using SPSS for Windows version 24.0 (SPSS, Inc, New York, NY, USA). The alpha level for statistical significance was set at $p < 0.05$.

RESULTS

A total of 100 neonates who were <32 weeks of GA were admitted to the NICU during the study period, but 29 were excluded from the analysis: 11 neonates underwent surgical procedures, seven died and 11 had incomplete data. As a result, 71 neonates were analysed: 24 (34%) were EPT infants and 47 (66%) were VPT infants. The characteristics of the infants are described in Table 1.

All 71 infants successfully reached full oral feeding before discharge and were discharged on *ad libitum* feeding. Our data showed significant differences in feeding performance, during both the tube feeding and oral feeding phases, when we compared the EPT and VPT infants (Fig. 1; $p < 0.01$).

Extremely preterm neonates needed significantly more time to reach FEN than VPT infants (Table 2, Fig. 1; $p < 0.001$) and then they needed longer to receive 10% of their mean daily intake orally (Table 2, Fig. 1). There was a significant difference between EPT and VPT babies with regard to the time needed to reach 100% oral feeding from 10% oral feeding (Table 2).

The median GA at which full oral feeding skills were reached was 37.1 (35.6–38.4) weeks in EPT infants and 34.7 (34.3–35.6) weeks in VPT infants ($p < 0.001$).

Infants were discharged about one week after they achieved independent oral feeding by mouth in both groups (Fig. 2). We found significantly lower weight increments

Table 1 Patients' characteristics

Characteristics	Total sample (n = 71)	VPT (n = 47)	EPT (n = 24)	p value
Gestational age at birth (weeks)	29.6 (27.1–31.0)	30.7 (29.6–31.3)	26.1 (25.6–27.2)	
Birthweight (g)	1120 (890–1480)	1350 (1120–1580)	815 (656–916)	<0.001
Days to reach FEN	9.5 (6–15)	8 (6–10)	16 (14–21)	<0.001
Days on conventional mechanical ventilation	8 (3–21)	3 (2–5)	14 (5.5–31)	<0.001
Days on continuous positive airway pressure ventilation	8 (2–29)	2.5 (1–8)	27.5 (8–44)	<0.001
Sepsis	34 (48%)	19 (40%)	15 (63%)	–
Bronchopulmonary dysplasia	7 (10%)	0	7 (29%)	–
Retinopathy of prematurity (≥Grade 3)	4 (6%)	0	4 (17%)	–
Necrotising enterocolitis	1 (1%)	1 (2%)	0	–

EPT = Extremely preterm; FEN = Full enteral nutrition; VPT = Very preterm.

Data are expressed as medians (IQRs), absolute numbers (%). A p value of <0.05 is considered statistically significant.

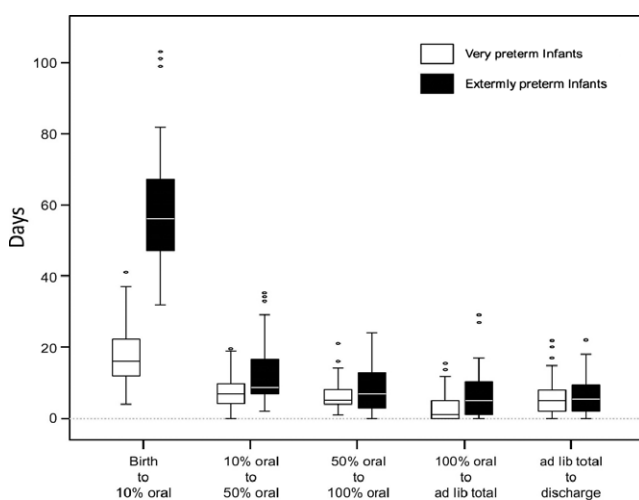


Figure 1 Acquisition of oral feeding skills by days of life. The box plot displays the number of days between certain milestones in oral feeding. VPT infants are indicated by white box plots and EPT infants by black box plots. Outliers are indicated by circles. Significant differences were found between the groups for the period from birth to 10% oral feeds ($p < 0.001$), 10% oral feeds to 50% oral feeds ($p = 0.026$), 10% oral feeds to 100% oral feeds ($p = 0.024$) and 100% oral feeds to *ad libitum* feeds ($p = 0.038$). EPT = Extremely preterm; VPT = Very preterm.

per kilogram of initial body weight in the EPT group, when compared to the VPT group, during the 10–100% oral feeds period (Table 3, Fig. 3).

DISCUSSION

Feeding challenges are well known to have an impact on nutrition, developmental outcomes and parents' interactions. Due to the lack of measuring tools to assess the feeding readiness of infants, and the paucity of evidence about the timing for initiating oral nutrition, there are still concerns about interventions to optimise feeding in preterm infants and what effect the timing has on weight gain.

Considerable research has reported that the factors that influenced the preterm infant's ability to feed effectively included neurobehavioural maturation, physiological stability, control of tone, behavioural state organisation and coordinated sucking, swallowing and breathing (1,15). Successful coordination of feeding has also been shown to be dependent on the adequate development of the upper airways structures, including the lips, palate, jaw, tongue, pharynx, larynx and oesophagus (15). There are different tools available to assess the readiness for sucking in preterm infants, but a 2016 Cochrane Review (15) found a lack of

Table 2 Number of days to make the transition to oral feeding in the total sample VPT and EPT infants

	Total sample (n = 71)	VPT (n = 47)	EPT (n = 24)	p value
Birth to FEN	9.5 (6.0–15.0)	8.0 (6.0–10.0)	16.0 (14.0–21.0)	<0.001
FEN to 10% oral	14.5 (7.0–29.0)	10.0 (4.0–15.0)	40.0 (28.0–45.0)	<0.001
Birth to 10% oral	23.0 (14.0–48.0)	17.0 (12.0–23.0)	56.0 (47.0–67.5)	<0.001
10% oral to 50% oral	8.0 (5.0–11.0)	7.0 (4.0–10.0)	8.5 (7.0–16.5)	0.026
50% oral to 100% oral	6.0 (3.0–9.0)	5.0 (4.0–9.0)	7.0 (3.0–13.0)	0.554
10% oral to 100% oral	15.0 (10.0–21.0)	13.0 (9.0–20.0)	16.0 (11.0–27.0)	0.024
100% oral to <i>ad libitum</i>	2.0 (0.0–6.0)	1.0 (0.0–5.0)	5.0 (1.0–10.5)	0.038
<i>Ad libitum</i> feeds to discharge	5.0 (2.0–8.0)	5.0 (2.0–8.0)	5.5 (2.0–9.5)	0.561

EPT = Extremely preterm; FEN = Full enteral nutrition; VPT = Very preterm.

Data are expressed as medians (IQRs). A p value of <0.05 is considered statistically significant.

Statistical analysis was carried out between VPT and EPT infants.

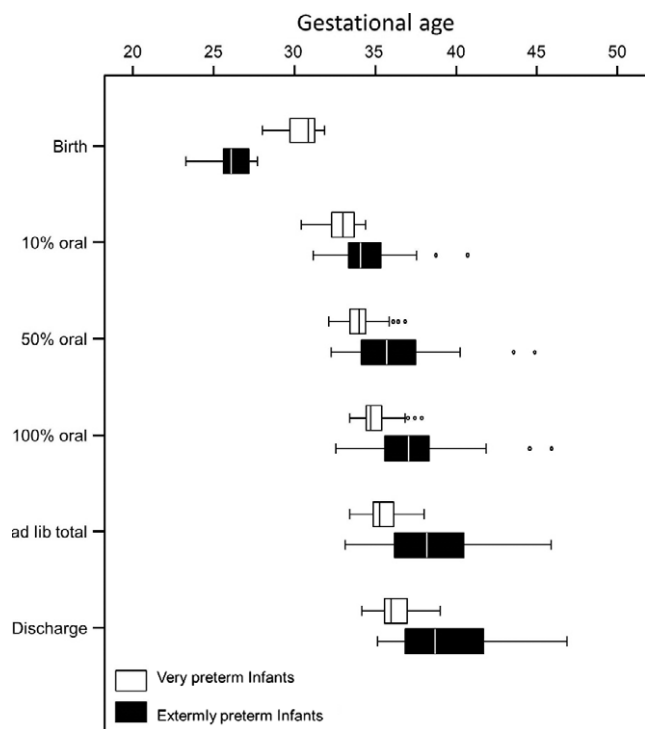


Figure 2 Acquisition of oral feeding skills in relation to gestational age (GA). Box plot displays the GA in relation to the milestones for oral feeding. VPT infants are indicated by white box plots and EPT infants by black box plots. Outliers are indicated by circles. Significant differences in GA were found between the groups for 10% oral feeds ($p < 0.001$), 50% oral feeds ($p = 0.001$), 100% oral feeds ($p < 0.001$), *ad libitum* feeds ($p < 0.001$) and discharge ($p < 0.001$). Differences in GA were not tested, since this time point was used to group the neonates into VPT and EPT. EPT = Extremely preterm; VPT = Very preterm.

evidence to estimate their effects on time to establish full oral feeding.

The present study describes full oral feeding achievement and weight gain in a cohort of preterm infants of <32 weeks of GA. All infants, regardless of GA, reached full oral feeding skills before discharge. VPT infants started oral feeding one week earlier than EPT infants, which was significantly earlier, they attained 100% oral feeding two weeks earlier and they reached *ad libitum* feeding three weeks earlier. Not surprisingly, VPT infants were

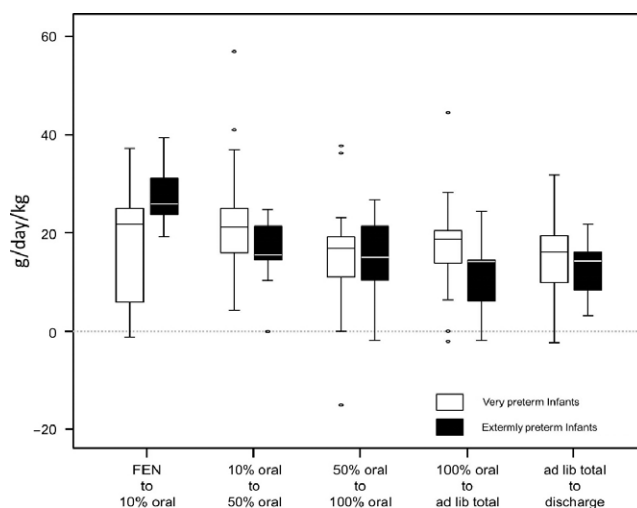


Figure 3 Weight gain in g/kg/day during acquisition of oral feeding skills. Box plot displays the weight gain between certain milestones of oral feeding. VPT infants are indicated by white box plots and EPT infants by black box plots. Outliers are indicated by circles. Significant differences were found between the groups for the time interval of FEN to 10% oral feeds ($p < 0.001$), 10% oral feeds to 50% oral feeds ($p = 0.033$), 10% oral feeds to 100% oral feeds ($p = 0.004$), 100% oral feeds to *ad libitum* feeds ($p = 0.003$) and *ad libitum* feeds to discharge ($p = 0.027$). EPT = Extremely preterm; FEN = Full enteral nutrition; VPT = Very preterm.

discharged two weeks earlier than EPT patients. Analysing the GA in detail, it was significantly higher in EPT group for the attainment of 10, 50 and 100% oral feeds. We set the first successful step towards oral feeding as the attainment of 10% oral feeding, which was 33 weeks of gestation in VPT infants and 34 weeks in the EPT group. Other studies have reported that the GA for first oral feeding skills ranged between 32 and 36 weeks (9,16). There is no clear consensus regarding the definition of the first successful oral feeding and this uncertainty may explain the wide range.

Our findings confirmed that GA at birth influenced the development of feeding skills. This was in accordance with Amaizu et al., who showed how the maturation of feeding skill levels depended on the infants' GA (13). Accordingly, our data showed that the main difference was the time needed to start oral feeding, which was 17 days in VPT infants and 56 days in EPT infants. There was no significant

Table 3 Growth velocity in g/kg/day in the total sample of VPT and EPT infants

	Total sample (n = 71) median (IQR)	VPT (n = 47) median (IQR)	EPT (n = 24) median (IQR)	p value
FEN to 10% oral	24.2 (13.9–27.2)	20.1 (6.3–25.1)	26.9 (24.2–31.8)	<0.001
10% oral to 50% oral	19.5 (15.3–23.6)	20.8 (16.2–23.8)	17.7 (14.4–21.7)	0.033
50% oral to 100% oral	15.8 (9.3–21.1)	17.4 (11.4–22.5)	13.0 (7.9–18.6)	0.057
10% oral to 100% oral	19.8 (17.4–23.2)	20.5 (18.3–23.9)	17.9 (14.0–20.9)	0.004
100% oral to <i>ad libitum</i>	14.9 (7.8–20.0)	18.3 (13.5–20.9)	11.0 (6.2–14.4)	0.003
<i>Ad libitum</i> to discharge	14.3 (7.4–18.7)	15.9 (11.2–19.9)	11.0 (6.5–14.7)	0.027

EPT = Extremely preterm; FEN = Full enteral nutrition; VPT = Very preterm.

Data are expressed as medians (IQRs). A p value of <0.05 is considered statistically significant.

Statistical analysis was carried out between VPT and EPT.

difference between the two groups in the time needed to achieve 50 and 100% oral feeding. This seems to indicate that after the infants attained a certain degree of feeding skills, there was no difference in their further feeding skills progression. However, our data also showed a significant difference in the time needed to attain *ad libitum* feeds, but this might be influenced by caregivers' hesitation to increase feeding in EPT infants.

There is evidence that babies born prematurely are considerably exposed to nonphysiological stimuli when they complete their development and this affects the main developmental milestones, including feeding readiness. Certainly, the most premature infants receive the highest number of invasive procedures and it is reasonable to assume that these experiences can explain our findings (17).

Several authors have shown that the introduction of an early oral feeding protocol resulted in earlier attainment of oral feeding skills (8,14). Indeed, our protocol included early prefeeding oral stimulation, regardless of the need for respiratory support.

The goal for the nutritional management of preterm infants is to achieve a growth rate and a composition of weight gain similar to those of a normal foetus. This strategy was initially proposed by the American Academy of Pediatrics (18) and subsequently indicated by the European Society of Paediatric Gastroenterology, Hepatology and Nutrition Committee on Nutrition (19) and several other authors (20,21). Despite these goals, poor postnatal growth is almost a universal problem among very low birthweight infants (22,23). The EPT infants in our study showed significantly less weight gain than those born VPT and the weight gain difference was more marked, particularly during the transition from 100% oral feeding to *ad libitum* feeds. A more detailed analysis during the transition from FEN to 10% oral feeding showed that weight gain was significantly higher in EPT than VPT babies. However, after the initiation of oral feeding, weight gain was significantly lower in the EPT than VPT infants. In the EPT group, it decreased significantly from 26.9 to 11 g/kg/day, which surprised us as it was markedly below the recommended standard for preterm growth. This finding raised the question of whether *ad libitum* feeding was the adequate approach in extremely immature infants. We cannot comment further on this because we have no data regarding the catch-up growth of our patients after discharge, but this topic certainly warrants further research.

Our study had some limitations. First, it was a single centre study; therefore, the conclusions that it has reached cannot be generalised. In addition, the confounding factors, such as comorbidities, were not evaluated, but it is reasonable to assume that they may have influenced the results (24–27).

CONCLUSIONS

This study confirmed that full oral feeding achievement was possible before discharge, even in EPT infants, using a unit feeding protocol that included prefeeding oral

stimulation and constantly assessing the infants' readiness to feed.

Our findings highlight the fact that GA at birth may have determined the time when the infants developed their oral skills. This is important because it showed that we needed more time to achieve full oral feeding in our EPT babies, and they clearly required close monitoring to recognise the signals for oral feeds readiness. Furthermore, this population showed a different growth rate to VPT babies, even though they received the same intake. This raises the question of whether expected daily weight gain should be targeted according to GA.

FINANCE

This study did not receive any specific funding.

CONFLICT OF INTEREST

The authors have no conflict of interests to declare.

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