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A nutritional program to improve outcome of very low birth weight infants

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SUMMARY

Background & aims: The growth of very low birth weight infants does not match intrauterine trajectories, likely due to inappropriate caloric intake. We therefore investigated whether modification of the standard nutritional schedule can impact postnatal growth.
Methods: We introduced a set of evidence-based strategies in a study group of infants ($n = 123$): 1) higher maximum intake of intravenous amino acids and lipids; 2) prioritisation of earlier enteral feeding; 3) faster attainment of full enteral feeds; 4) daily adjustment of enteral feeds according to growth trajectory; and 5) utilisation of an electronic pre-structured prescription ordering system that tracks individual growth and energy intake. These infants were compared with a control group ($n = 115$) in a pre/post retrospective cohort study.
Results: The study group achieved a higher caloric intake, attained full enteral feeds 5 days earlier, and returned to their birth weight more rapidly than the control group. At 36 weeks postmenstrual age, infants who had been born at <30 weeks were heavier (Δ260 g) but had a similar percentage fat mass. Those born at <28 weeks had a larger head circumference (Δ1.4 cm) and lower sepsis rate (7.8%).
Conclusions: Optimization of early postnatal nutrition and daily adjustment of milk intake according to weight gain improved growth, without any unfavourable outcomes for body composition and neurodevelopmental follow-up.

1. Introduction

Extrauterine growth of very low birth weight (VLBW) infants differs from intrauterine growth trajectories, and their weight at discharge is often low.[1–3] The standard nutritional guidelines that are implemented in intensive care units only partially fulfil the nutritional needs of these VLBW infants,[4] which often leads to cumulative nutritional deficits,[5,6] inadequate growth,[1–3] impaired neurological development[7–11] and a significantly higher risk of health problems in later life.[12]

Given the inadequacies in the standard feeding regimens, there is a need for an improved feeding strategy to improve growth and outcomes for VLBW infants. Recent studies have shown that a higher postnatal parenteral intake of nutrients,[13–15] early enteral nutrition[16,17] and a higher enteral volume[18] enable improved growth. We therefore introduced a set of evidence-based strategies aimed at improving the nutritional standards for VLBW infants.

The set of strategies that we introduced involved: increased intake of amino acids and lipids through both a higher starting rate and a faster increase in the rate, as well as the introduction of an absorption factor of 0.75 when calculating the required parenteral nutrition, to take into account the actual metabolic bioavailability of enteral nutrition; the initiation of enteral feeding within 6 h of birth; a decrease in the time taken to achieve full enteral feeding; and adaptation of enteral intake on a daily basis to enable infants to follow projected growth percentiles. In addition, we supported ward rounds with point-of-care computing and improved compliance through the introduction of an electronic pre-structured prescription ordering system that gave day-by-day instructions for the nutrition of the infants. This system monitored the daily individual growth of each infant, as well as energy and nutrient

Non-standard abbreviations: PMA, postmenstrual age; VLBW, very low birth weight; CLD, chronic lung disease; NEC, necrotising enterocolitis; IVH, intraventricular haemorrhage; ROP, retinopathy of prematurity; SGA, small for gestational age; AGA, appropriate for gestational age; DXA, dual energy X-ray absorption; BMC, bone mineral content; FM, fat mass; LBM, lean body mass; MFED, Munich Functional Developmental Diagnostic; VON, Vermont Oxford Neonatal Network.

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intake, allowing us to adapt to the specific nutritional requirements of each infant on a daily basis.

To determine the efficacy of this set of practice changes, we analyzed the nutritional intake, growth and body composition of VLBW infants according to both the original standard and new nutritional strategy during two separate time periods.

2. Materials and methods

This study was approved by the Ethics Committee of the University of Greifswald, Germany.

2.1. Study population

We performed a pre/post retrospective cohort study of preterm infants with a birth weight <1500 g and born at postmenstrual age (PMA) ≤34 weeks, treated during the 6.5 years from June 2001 to December 2007 at the neonatal intensive care unit of the University of Greifswald, Germany. The neonatal intensive care unit offers the full range of neonatal care services providing 14 level 3 beds and 15 level 2 beds.

The study group of infants were admitted during the period from May 2005 to December 2007, after an evidence-based set of practice changes to our feeding strategy had been introduced. These infants were compared with a historic control group that included infants from June 2001 to January 2005, who had received nutrition according to the prevailing nutritional standards. Infants who were born during the run-in period for the new feeding practices (from February 2005 to April 2005) were excluded from the study. In addition, we excluded infants who died before 36 weeks PMA, infants with pathologies that affect intestinal function and head circumference, and infants who were early transferrals to other units.

To improve compliance with the new feeding program, an electronic pre-structured prescription ordering system containing a W-LAN-based nutritional calculator with ready-to-use print outs for pharmacy and bedside, and electronic charts was introduced at the same time as the new feeding strategies (this software was developed in house by Christian Niesytto and Niels Rochow [supplementary data]). This system gave day-by-day instructions for the nutrition for infants according to the guidelines and required an additional confirmatory step for deviations from the guidelines. Compliance to the new feeding program was monitored daily during the handover period by the attending neonatologist.

2.2. Nutritional regimes

Enteral and parenteral intakes were calculated based on weight, PMA at birth and day of life (Table 1). The components of the parenteral nutrition were determined from the difference between requirements (defined by our local standards for nutritional levels) and enteral intake (fluid volume, carbohydrates, proteins and fats). The parenteral nutrition was estimated assuming a correction factor for bioavailability that took into account enteral absorption, loss of milk in feeding lines, and gastric reflux. The local standard for this factor was 0.75 for the study period and 1.0 for the control period.

The initial volume of intake for preterm infants with a birth weight of <1500 g but ≥1000 g was 80 mL/kg/d and for those with a birth weight of <1000 g it was 90 mL/kg/d; this was then increased daily by 20 mL/kg/d until a volume of ≥160 mL/kg/d was attained. For extremely preterm infants, the initial volume of fluid was increased per week born before 27 weeks PMA by additional 10–20 mL/kg/d. All infants experienced a period of postnatal weight loss, during which birth weight was used to calculate the nutritional requirements. Once the infants regained their birth weight, the actual body weight was used. Urine output was monitored and total fluid intake was adjusted at the discretion of the attending neonatologist.

Table 1
Nutritional standards for the first days of life during the study period (May 2005 to Dec 2007) and control period (Jun 2001 to Jan 2005). Outlined are total nutritional requirements (including both parenteral and enteral intake). The correction factor for bioavailability of enteral nutrition was 0.75 in the study group and 1.0 in the control group.

Day of life	Study and control period	Study period		Control period	
	Glucose [mg/kg/min]	Proteins [g/kg/d]	Lipids [g/kg/d]	Proteins [g/kg/d]	Lipids [g/kg/d]
1	4 mg/kg/min,	1.5	1.5	1.0	1.0
2	daily increases	2.0	2.0	1.0	1.0
3	by 1 mg/kg/min to a	2.5	2.5	1.0	1.0
4	maximum of 12 mg/kg/min	3.0	3.0[a]	2.0	2.0
5	(blood glucose <7 mmol/L)	3.5	3.5[a]	2.5	3.0
6		3.5	3.5[a]	2.5	3.5

[a] infants <1000 g received a maximum of 2.5 g/kg/d lipids parenterally.

Enteral feeding was started within 6 h of birth, with 10–15 mL/kg/d given at intervals of 2 h. Maltodextrin (15%) was administered for the first two feeds, then the infants received breast milk or partially hydrolyzed preterm formula (energy: 80 kcal/100 mL; carbohydrate: 7.7 g/100 mL; protein: 2.4 g/100 mL; fat: 4.4 g/100 mL). Supplementation of breast milk with fortifier was started with enteral feeding at volumes of ≥120 mL/kg/d. During the first 2 days, infants received 50% of the recommended dose of the fortifier, followed by the full recommended dose from day 3 onwards.

After full enteral feeding was attained, the enteral intake was adjusted on a day-to-day basis with the aim of keeping the infants as close as possible to their growth percentiles (using charts for individual growth trajectories that were based on calculations similar to the Fenton growth charts[19]). The trajectory of the individual growth curve was determined along the continuum between the birth percentile and one standard deviation below the birth percentile. To achieve the required weight gain, feeding volumes were increased up to 200 mL/kg/d in steps of 10 mL/kg/d at the discretion of the attending neonatologist. After 200 mL/kg/d were reached the milk was additionally fortified with Duocal® (Nutricia, Germany).

2.3. Data management and statistical analysis

Data extracted from the infants' charts included daily weight, weekly body length and head circumference, daily enteral and parenteral intake, body composition before discharge (calculated from whole-body dual energy X-ray absorption (DXA) scans with the Hologic QDR 1500 (Waltham, MA, USA) in a single-beam mode[20]), major illnesses, and surgery.

Mortality and major morbidity of all admitted infants were analyzed to control for any trends associated with the different nutritional programs during the study and control periods. The effects on growth and nutrition were analyzed in a subgroup of infants without pathologies that affect intestinal resorption and head circumference, and without infants who were early transferrals to other units. Furthermore data obtained from infants in the growth analysis subgroup were analyzed during the neurodevelopmental follow-up at 24 months of age (Fig. 1).

The period of stable growth was defined as the phase beginning on the day of life when the infant returned to its birth weight until the infant reached a PMA of 36 weeks.

For the statistical analysis, enteral calories, enteral carbohydrates, enteral proteins and enteral fat intake were adjusted for