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Enteral Nutrient Supply for Preterm Infants: Commentary From the European Society for Paediatric Gastroenterology, Hepatology, and Nutrition Committee on Nutrition

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ABSTRACT

The number of surviving children born prematurely has increased substantially during the last 2 decades. The major goal of enteral nutrient supply to these infants is to achieve growth similar to foetal growth coupled with satisfactory functional development. The accumulation of knowledge since the previous guideline on nutrition of preterm infants from the Committee on Nutrition of the European Society of Paediatric Gastroenterology and Nutrition in 1987 has made a new guideline necessary. Thus, an ad hoc expert panel was convened by the Committee on Nutrition of the European Society of Paediatric Gastroenterology, Hepatology, and Nutrition in 2007 to make appropriate recommendations. The present guideline, of which the major recommendations are summarised here (for the full report, see *http://links.lww.com/A1480*), is consistent with, but not identical to, recent guidelines from the Life Sciences Research Office of the American Society for Nutritional Sciences published in 2002 and recommendations from the handbook *Nutrition of the Preterm Infant. Scientific Basis and Practical Guidelines*, 2nd ed., edited by Tsang et al., and published in 2005. The preferred food for premature infants is fortified human milk from the infant's own mother, or, alternatively, formula designed for premature infants. This guideline aims to provide proposed advisable ranges for nutrient intakes for stable-growing preterm infants up to a weight of approximately 1800 g, because most data are available for these infants. These recommendations are based on a considered review of available scientific reports on the subject, and on expert consensus for which the available scientific data are considered inadequate. ***JPGN 50:000–000, 2010.*** **Key Words:** Child development—Embryonic and foetal development—Nutritional requirements—Premature infant feeding.

In 1987 the European Society of Paediatric Gastroenterology (ESPGAN), and Nutrition published recommendations on nutrition and feeding of preterm infants (1). Even though extensive reviews on the topic have recently been published (2,3), the ESPGHAN Committee on Nutrition considered it necessary to review the recommendations on nutrient needs of preterm infants.

An expert group reviewed the existing evidence and prepared draft manuscripts on advisable intakes of macro- and micronutrients for preterm infants. These proposals were reviewed and discussed in detail at a scientific workshop organised by the charitable Child Health Foundation (*www.kindergesundheit.de*) in March 2007. This meeting was attended by observing experts in infant formula design and manufacturing (Observers from the dietetic industry at the scientific workshop held to discuss the draft recommendations with invited expert guests (in alphabetical order): H. Böckler, G. Boehm, C. Garcia, F. Haschke, J. Wallingford), who were asked to provide advice on the feasibility of producing food products based on the recommendations made.

The aim of this commentary is to provide guidance on quantity and quality of nutrients needed for preterm infants, so as to achieve growth similar to foetal growth coupled with satisfactory functional development. The recommendations relate to ranges of enteral intakes for stable-growing preterm infants up to a weight of approximately 1800 g, because most data are available for these infants. No specific recommendations are provided for infants with a weight below 1000 g because data are lacking for this infant group for most nutrients, except for protein needs. The needs of infants with specific diseases (eg, bronchopulmonary dysplasia, congenital heart disease, short bowel syndrome) and those receiving parenteral nutrition have been reviewed recently (4) and are not specifically addressed in this commentary.

The Committee advocates the use of human milk for preterm infants as standard practice, provided it is fortified with added nutrients where necessary to meet requirements. Parents and health care providers should be aware that human milk composition may vary for the duration of lactation, within the day, and even during 1 expression. Also, the treatment following expression (eg, storage, pasteurisation) may influence composition. As an alternative to human milk, preterm formula may be used. This commentary focuses on providing guidance on appropriate nutrient intakes with fortified human milk or formula.

Recent extensive reports on this topic (2,3) and recommendations on nutrient supply for term infants (5) have been taken into account in preparing this commentary. A MEDLINE search was performed for publications on preterm nutrition. For several nutrients, however, there is insufficient evidence on which to base definitions of lower and upper intake levels. When sufficient data were not available, intakes provided with human milk feeding, available human milk fortifiers, and with preterm infant formulae were considered.

Ranges of advisable nutrient intakes are expressed both per kilogram body weight per day and per 100 kcal (Table 1). Calculation of the latter values was based on the minimum energy intake of $110\,\mathrm{kcal}\cdot\mathrm{kg}^{-1}\cdot\mathrm{day}^{-1}$ that we chose to recommend. Thereby, the ranges of nutrient intakes per 100 kcal will ensure that the infant receives the minimum or maximum of each specific nutrient at an intake of $110\,\mathrm{kcal}\cdot\mathrm{kg}^{-1}\cdot\mathrm{day}^{-1}$. One should be aware that at higher energy intakes, the individual nutrient should not exceed an acceptable maximum level of intake.

TABLE 1. *Recommended intakes for macro- and micronutrients expressed per mg · kg^{-1} · day^{-1} and per 100 kcal unless otherwise denoted*

Min–max	Per kg^{-1} · day^{-1}	Per 100 kcal
Fluid, mL	135–200	
Energy, kcal	110–135	
Protein, g <1 kg body weight	4.0–4.5	3.6–4.1
Protein, g 1–1.8 kg body weight	3.5–4.0	3.2–3.6
Lipids, g (of which MCT <40%)	4.8–6.6	4.4–6.0
Linolenic acid, mg*	385–1540	350–1400
α-linolenic acid, mg	>55 (0.9% of fatty acids)	>50
DHA, mg	12–30	11–27
AA, mg†	18–42	16–39
Carbohydrate, g	11.6–13.2	10.5–12
Sodium, mg	69–115	63–105
Potassium, mg	66–132	60–120
Chloride, mg	105–177	95–161
Calcium salt, mg	120–140	110–130
Phosphate, mg	60–90	55–80
Magnesium, mg	8–15	7.5–13.6
Iron, mg	2–3	1.8–2.7
Zinc, mg‡	1.1–2.0	1.0–1.8
Copper, μg	100–132	90–120
Selenium, μg	5–10	4.5–9
Manganese, μg	≤27.5	6.3–25
Fluoride, μg	1.5–60	1.4–55
Iodine, μg	11–55	10–50
Chromium, ng	30–1230	27–1120
Molybdenum, μg	0.3–5	0.27–4.5
Thiamin, μg	140–300	125–275
Riboflavin, μg	200–400	180–365
Niacin, μg	380–5500	345–5000
Pantothenic acid, mg	0.33–2.1	0.3–1.9
Pyridoxine, μg	45–300	41–273
Cobalamin, μg	0.1–0.77	0.08–0.7
Folic acid, μg	35–100	32–90
L-ascorbic acid, mg	11–46	10–42
Biotin, μg	1.7–16.5	1.5–15
Vitamin A, μg RE, 1 μg ~ 3.33 IU	400–1000	360–740
Vitamin D, IU/day	800–1000	
Vitamin E, mg (α-tocopherol equivalents)	2.2–11	2–10
Vitamin K_1, μg	4.4–28	4–25
Nucleotides, mg		≤5
Choline, mg	8–55	7–50
Inositol, mg	4.4–53	4–48

AA = arachidonic acid; DHA = docosahexaenoic acid; IU = interna-international unit; MCT = medium-chain triacylglycerols.

Calculation of the range of nutrients expressed per 100 kcal is based on a minimum energy intake of 110 kcal/kg.

* The linoleic acid to α-linolenic acid ratio is in the range of 5 to 15:1 (wt/wt).

† The ratio of AA to DHA should be in the range of 1.0–2.0 to 1 (wt/wt), and eicosapentaenoic acid (20:5n-3) supply should not exceed 30% of DHA supply.

‡ The zinc to copper molar ratio in infant formulae should not exceed 20.

Although the recommended ranges of nutrient intakes are considered reasonable, a high degree of uncertainty remains and hence the provision of nutrient intakes outside of the specified ranges is not discouraged if justified by good reasons. Nevertheless, it must be noted that using levels found in available commercial products without apparent problems as the basis for providing guidelines is less than satisfactory, because subtle adverse affects may not be detected without conducting adequate randomised controlled trials. Such trials can also be aimed at obtaining data on suitability and safety of intakes that are outside the specified ranges.

A detailed report is available electronically (*http://links.lww.com/A1480*), whereas this commentary focuses on the major changes that some of the specific recommendations underwent. A table is provided with specific recommendations for all nutrients, including nutrients that are not discussed separately in this commentary.

FLUID

Randomised controlled trials on enteral fluid intake of preterm infants are lacking as are studies comparing different fluid volumes providing identical nutrient intakes. From data of combined parenteral/enteral regimens, and assuming full enteral absorption, it follows that fluid volumes between 96 and 200 mL · kg^{-1} · day^{-1} are tolerated, and that these values may serve as lower and upper limits (6), and that postnatal intakes at the lower range is likely to minimise risk of long-term morbidity such as bronchopulmonary dysplasia and patent ductus arteriosus. It is important to note that fluid volumes needed for enteral nutrition are influenced by osmolarity and renal solute load and are not synonymous with actual water needs.

We regard 135 mL · kg^{-1} · day^{-1} as the minimum fluid volume and 200 mL · kg^{-1} · day^{-1} as a reasonable upper limit. For routine feeding, rates of 150 to 180 mL · kg^{-1} · day^{-1} nutrient intake when standard formula or fortified breast milk is used are likely to achieve meeting nutrient requirements. Some infants may need higher volumes to meet requirements of substrates other than fluid.

ENERGY

Recommendations for energy intake are based on the assumption that growth and nutrient retention similar to intrauterine references are appropriate. Yet we must make allowances for extrauterine environment and differences in nutrient supply and metabolism (eg, the foetus receives only a small proportion of energy as fat). Using intrauterine growth as a standard should involve not only achieving similar weight gain but also body composition, even though a higher extrauterine fat deposition may be needed to provide thermal and mechanical protection.

Studies in the 2 decades since the ESPGAN recommendations (1) have provided data on longer-term outcomes, and there are indications that rapid infant weight gain in term infants may be associated with adverse