

## Low Birthweight Neonates: Aspects of Feeding in Resource-limited Settings

Suraj Gupte\*

Department of Pediatrics, Mamata Medical College and Hospitals, Telengana, India

\*Corresponding Author: Suraj Gupte, Professor and Head, Department of Pediatrics, Mamata Medical College and Hospitals, Khammam 507002, Andhra Pradesh, India.

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### Abstract

Major goal of optimal nutrition of low birth weight (LBW) babies is to improve their immediate survival and achieve optimal short-term and long-term growth and development. While deciding the feeding approach, the weight as well as maturity of the neonate should be taken into consideration. Breastfeeding should be the first choice in babies with good sucking, swallowing and respiratory coordination. Intravenous (IV) fluids or oral/ gavage feeding employing expressed breast milk (EBM) can be initiated in others. Usually, neonates < 1000g/<28 weeks need parenteral nutrition (PN). In the non-availability of this facility, they may be initiated on IV fluids. Even infants on parenteral nutrition should be started on minimal enteral nutrition (MEN) i.e. trophic feeding, as soon as workable. This is a must for priming the gut. Babies not on direct breastfeeding need to be exposed to nonnutritive sucking (NNS).

For enteral feeding human milk is the milk of choice. It may well be supplemented with a human milk fortifier (HMF) or a preterm formula to meet the nutritional needs.

Growth monitoring during and post-discharge is important to identify growth failure and for timely corrective intervention(s).

**Keywords:** Expressed breast milk; Human milk fortification; Low birth weight; Minimal enteral nutrition; Necrotizing enterocolitis; Non-nutritive sucking; Nutritional needs; Parenteral nutrition; Preterm neonate; Self feeding; Supplements; Tube feeding

### Introduction

According to conservative estimates, annually, some 20 million infants are born worldwide with a low birth weight (<2500g), usually as a result of prematurity or intrauterine growth retardation. These infants form nearly 15% of the total livebirths. They are responsible for around 75% of neonatal mortality globally.

Imagine the former President of United States, John F. Kennedy's son, Patrick Bouvier, born 2100g weight, dying 2 days after birth in 1963 for want of requisite facilities [1].

The scenario has undergone a sea change during the last few decades that have witnessed a considerable improvement in survival of the low birth weight (LBW) babies with unprecedented progress in the field of neonatology not just in prosperous countries but also in resource-limited countries.

The contribution of improved nutrition delivery, including early institution of enteral and parenteral feeding, in this context has been significant. Additional improvements in the nutritional strategies with emphasis on moderately aggressive "early feeding with caution" is likely to further increase their survival as also their growth and development, including the neurodevelopment, which are at stake, especially in the very low birth weight (VLBW) babies and extremely low birth weight (ELBW).

### Feeding Difficulties and Handicaps

Self-feeding is not an issue in term LBW infants. However, it may become a problem in the very low birth weight (VLBW) neonate on account of the factors which are mostly related to immaturity of the gastrointestinal system (Box 1) [2,3].

- a. Higher nutritional requirement to make up the deficit in weight.
- b. High frequency of suckling difficulties.
- c. Inappropriate coordination between suckling and swallowing.
- d. Failure to hold a large feed in stomach, resulting in abdominal distension.
- e. Regurgitation from lax cardio-esophageal sphincter.
- f. Poor tolerance for saturated fatty acids.
- g. Increased susceptibility to necrotizing enterocolitis

**Box 1:** Bottlenecks in self-feeding in LBW infants.

**Nutritional Needs**

Nutritional needs of the LBW infants are at variance with those of term infants [2-6].

**Energy:** According to estimates, the LBW infant requires, on an average, 140 (120-150) kcal/kg/day for achieving and maintaining satisfactory growth velocity. Approximately, 200 ml of milk is required to meet this demand. Attempts to attain this target right at the outset often prove futile since the infant is simply unable to cope with this much feed. A realistic and practical approach is to aim at achieving this target by second week. In VLBW infants, a further extension of a week or even longer is needed.

**Protein:** According to European Society of Pediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN)'s most recent guidelines, 3.5-4.5 g/kg/day of protein is good enough for LBW infants [7]. The gut is known to utilize a considerable amount of protein (50% on average), which is not available systematically. Also, only 20% of specific amino acids are able to reach systemic circulation. In the wake of these observations, higher amino-acid intake of 4- 4.5 g/kg/day with preterm formulas is the current recommendation.

Any intake outside this range may prove harmful to the infant. Higher intake may cause retention of fluid and solute as also high blood urea on account of renal immaturity. Too rapid weight gain occurring in this situation is not in the interest of the baby. On the contrary, low protein intake may cause hypoproteinaemic edema and poor weight gain, further worsening the baby's nutritional status.

ESPGHAN categorically recommends against tapering off parenteral amino acids before at least 75 ml/kg/day human milk/formula is provided enterally.

**Vitamins:** Besides vitamin K at birth, the neonate needs multivitamins (especially vitamins A, C, D and E), iron and folic acid, calcium, phosphorus, etc. subsequently.

Early feeding i.e. within 3-12 hours is the current recommendation. Most centers give the first feed at about 3 hours of age. A careful supervision and vigilance cuts down the risk of aspiration in early feeding.

**Minerals:** Low dose iron supplements, 2-3 mg/kg/day, is recommended from 2-4 weeks of age, provided that the infant is on total enteral nutrition, is showing reasonable weight gain and is infection-free. Else, he runs the risk of

- Precipitation of vitamin E deficiency
- Hemolytic anemia
- Reduced absorption of zinc (leading to acrodermatitis enteropathica) and copper (leading to psychomotor retardation, hypotonia, osteoporosis and sideroblastic anaemia)

- Overgrowth of *E. coli* through binding of lactoferrin that normally is a robust inhibitor of this bacterium.
- Risks of delayed feeding include
- Icterus,
- Hypoglycemia,
- Metabolic acidosis,
- Metabolic acidosis, and
- Brain damage.

### Goals of Nutrition [8]

The goals of LBW infant's nutrition include:

- a. Short-term growth,
- b. Prevention of neonatal morbidity,
- c. Long-term favorable outcomes.

### Short-term Growth

Preterm infant fed preterm milk demonstrate increase in weight, length and occipitp-frontal circumference (OFC) as well as retention rates of various nutrients comparable to those for the foetus of similar post-conception age. The preterm infant's own mother's milk produced during early postpartum period offers nutritional advantage because of:

- Higher protein content.
- Higher electrolyte concentrations.
- Better absorption.

It now stands established that fat absorption in preterm babies, fed their own mother's milk, is significantly higher than in a similar group of infants fed cow's milk formula. Long-chain polyunsaturated fatty acids (LCPUFAs), which are important for mental and visual development, are shown to be higher in breast milk.

### Preventing Neonatal Morbidity

Reduced incidence of necrotizing enterocolitis (NEC) and acute inflammatory disease has been observed in preterm infants fed mother's milk in comparison to formula milk. The quantity of host defense factors in preterm milk are greater than in term milk. Moreover, the disease seems to be less severe and the prevalence of intestinal perforation lower during the course of the disease in infants who receive human milk before diagnosis compared with formula, 7% v/s 39%, respectively. A decreased rate of various infections in premature infants fed human milk compared with those fed infant formula is a common observation.

### Long-term Outcome

The existence of a relationship between early diet and development of hypertension, hypercholesterolemia and ischemic heart disease is well known. The receipt of unfortified human milk during hospitalization has been associated with greater intellectual performances score compared with the receipt of formula in former premature infants. Premature infant fed donor human milk is on record to have more advantages in psychomotor development at 18 months of age than infants fed preterm formula.

**Method of Feeding/Providing Nutrition**

Though the essential principles of nutrition of preterm/ LBW babies remain more or less same, feeding approaches may vary from center to center [2-6]. Over the years, quite a few protocols have appeared [8-12]. The slow vs rapid feeding has been studied by Krishnamurthy, *et al.* [13].

Based on our experience spread over decades in India, the following flexible general guidelines may be modified according to the merits of the situation, including the availability of facilities.

Before embarking on details, it is pertinent to have a broad idea of the available various modalities of nutrition delivery for the benefit of such babies. The decision about the modality in a particular situation is based on extent of maturity and weight of the premature/LBW baby (Box 2).

**LBW > 2000 g/ > 34-week gestation**

Direct breast feeding should be the choice.

Else, cup-spoon, paladai or nasogastric tube feeding may be started, employing expressed breast milk (EBM).

Nonnutritive suckling should be encouraged.

**LBW 15-2000 g/32-34-week gestation**

Enteral feeds, gradually shifting to cup-spoon or paladai feeding and then to breastfeeding

Distressed /sick neonates may initially be started on IV fluids.

**VLBW 1000-1500 g /30-32-week gestation**

Consider parenteral nutrition/IV fluids in sick neonates

Else, gavage feeding

**ELBW < 1000 g/30-week gestation**

Parenteral nutrition if feasible. Else, IV fluids Once the neonate becomes stable, start minimal enteral nutrition (MEN), 10 ml by gavage every 2 hr. and increase by 10 ml/kg/day if tolerance is good.

**Box 2:** Broad recommendations for feeding of LBW neonates.

**Breastfeeding**

Many LBW infants, especially those weighing > 1800 g, are strong enough to suckle well from the breast. Direct breastfeeding (Figure 1) should be encouraged in them. However, care should be exercised to safeguard against distension of abdomen. This is best achieved though small feeds at frequent intervals.

Breastfeeding should be considered as the “preferred feeding” for all LBW babies. When it is not workable for some reason, gavage feeding (tube feeding) should be the choice, employing mother’s own expressed milk (Figure 2). There is sufficient evidence that necrotizing enterocolitis is far less in LBW infants fed mother’s milk than those on artificial feed. Further, LBW infants on own mother’s milk are known to grow faster than those on another woman’s milk.

**Alternative Methods of Milk Feeding****Gavage (Tube) Feeding**

It is needed in:

- LBW infants weighing < 1000/1200 g or < 30 weeks’ gestation after initial stabilization with IV fluids.
- LBW infants weighing 1000-1500 g or < 34 weeks’ gestation.

- Baby getting tired quickly.
- Baby taking > 20 min to finish the feed.

Any of the two, intermittent or continuous methods of feeding, may be employed depending on the need for short term or long-term feeding.

**Nasojunal/ Nasoduodenal Feeding**

In order to cut down chances of regurgitation and aspiration of feed and achieving better absorption from larger surface area of the duodenal/jejuna wall, this method provides a simple means of delivering feeds beyond pylorus.

**Intravenous (Central) Feeding**

During first 2 days, for LBW of SGA type, 90-100 ml/ kg of 5-10 % glucose is recommended. For LBW of short gestation type, 60-70 ml/kg of 5-10 % glucose suffices.

Since the LBW needs extra sodium and potassium, N/ 5 saline with 15% potassium chloride (1 ml added to 100 ml infusate) should replace the 5-10% glucose after 2 days. The readymade Isolyte-P serves well as an alternative.



**Figure 1:** Low birthweight (LBW) infant weighing 1900 g receiving direct breastfeeding.



**Figure 2:** Very low birthweight (VLBW) infant weighing 1300g receiving gavage feeding employing mother's own expressed breast milk (EBM).

### Parenteral Nutrition

It may become mandatory to resort to parenteral nutrition in the following life-threatening situations in which enteral feeding has failed to establish or central feeding is not possible for prolonged periods:

- ELBW babies (<1000g).
- LBW babies unlikely to attain full enteral nutrition by day 5 on account of some associated problem

such as necrotizing enterocolitis, intractable diarrhea surgically correctable gastrointestinal anomaly(omphalocele, gastroschisis, tracheoesophageal fistula, malrotation with volvulus, diaphragmatic hernia, etc.), extensive bowel resection.

This regimen provides adequate fluids and electrolytes, energy (from glucose, protein and lipids), amino acids and vitamins and micronutrients for sustained growth of the LBW babies. With this method, providing around 100 kcal/kg/24 hours, a weight gain of 15 g/kg/24 hours is likely to be attained in the first week.

Parenteral nutrition may be carried out employing an indwelling central venous catheter (per cutaneous or surgically-placed) or through a peripheral vein.

It is important to be vigilant about the complications, both vascular catheter-related and metabolic, including sepsis.

### Some Related Important Issues

#### Expressed Breast Milk

EBM should be first choice for oral and gavage feeding when direct breastfeeding is not workable. Milk of the LBW baby's mother provides higher protein and calories. It is, therefore, not only species-specific but also baby specific on account of its best suitability for the infant. Expression of milk can be carried out by mother's attendant though mother herself is the best for this purpose. The choice about the manual expression or the use of a breast pump is influenced by the existing circumstances as well as mother's attitude.

In case enough EBM from the biologic mother is not readily available, it may be collected from another lactating healthy mother/human milk bank (if available).

Resort to top milk is indicated only in case of non-availability of breast milk. It should be for a short period only and breastfeeding resumed as soon as possible.

#### Feed Intolerance

It is a common observation that when oral feeding is initiated in due course, it may not be well tolerated, especially in some VLBW and many ELBW infants. Conventional criteria for intolerance include

- Prefeed gastric residual volumes (GRVs),
- Color of GRVs, and
- Associated clinical manifestation (say abdominal distension, vomiting, blood in stool, apnea, bradycardia) [21].

Whether feeding should be limited in such cases is best left to the judgment of the attending doctor. In select cases with suspicious physical signs, abdominal imaging may well be in order.

In our considered opinion, feeds should be withheld in the event of bilious vomiting (often pointing to an intestinal obstruction or ileus) and hemorrhagic residues.

Some infants with feeding intolerance may benefit from continuous feeding. Such a feeding improves feeding tolerance and lowers energy expenditure [22].

### Nutritional Supplements

Preterm human milk, though superior to pooled term milk, is deficient in iron, calcium, phosphorus, zinc and copper. It provides more proteins and energy but the preterm LBW infant needs yet more of these. EBM, therefore, works better when supplemented with human milk fortifier or individual nutrients. At present, the only available HMF in India is Lactodex-HMF (Raptakos-Brett).

### Human Milk Fortification [14-17]

At 2 weeks of age (by this time, the baby is expected to take 120 ml/kg/24 hours) nelson, a human milk fortifier may be added to EBM for providing extra protein, energy and micronutrients. The dose of Lactodex-HMF, the sole product available in India at present, is 2g for 50 ml of EBM [5]. The resultant fortified EBM provides additional 0.2g protein, 0.19g fat, 1.2g carbohydrate plus calcium, phosphorus, vitamins, minerals and trace elements.

In the event of non-availability of breast milk, a special preterm formula needs to be employed.

The following developments should be considered a matter of concern:

- An abrupt increase in frequency (>8/24 hours) of motions.
- Watery motions
- Blood (even occult) in stools

### Supplements

- Vitamin K: Right at birth, 1 mg vitamin K should be given intramuscularly.
- Multivitamin drops: At 2 weeks, multivitamin (including folic acid) drops should be introduced.
- Iron: From 4 weeks, low-dose (2-3 mg/kg/ day) iron supplementation should be started to combat early onset of physiological anaemia from postnatal suppression of erythropoiesis as a consequence of more rapid growth than in full-term babies [18].
- Vitamin A, D and E, calcium and phosphorus: Supplementation with these micronutrients is recommended, especially in case of VLBW infants.

### Prebiotics and Probiotics

The claims of pre- and probiotics reducing the risk of NEC and cutting short the time for attaining full enteral nutrition in ELBV and VLBW babies have been examined threadbare by the ESPGHAN Nutrition Committee[7]. According to the Committee, the presently available data do not permit recommending the routine use of prebiotics or probiotics as food supplements in preterm/LBW infants.

### Nonnutritive Suckling

The LBW infant, being kept on IV fluid/nutrition or gavage (tube) feeding, should be given experience of suckling by providing opportunity to suckle the empty breast [2,19,20]. This experience stands the baby in good stead later at the time of transition to nutritive suckling.

Additional reason for giving non-nutritive suckling include prematurity, low birthweight or such illnesses as birth asphyxia, septicemia, etc. There is evidence that such an exposure contributes to improved transition to nutritive suckling.

### Growth Monitoring

Regular growth monitoring of LBW infants assists in

- Assessing the nutritional status and adequacy of feeding;
- Identifying the infants with inadequate weight gain.

**Anthropometric Monitoring**

All LBW infants should be weighed daily till the time of discharge from the hospital. The goal is to achieve postnatal growth simulating the intrauterine growth [4].

Anthropometric parameters such as length and head circumference should be recorded weekly.

Both term and preterm LBW infants tend to lose weight (about 10% and 15% respectively) in the first 7 days of life. They regain their birth weight by 10-14 days. Thereafter, the weight gain should be at least 15-20g/kg/day till a weight of 2-2.5 kg is reached. After this, a gain of 20 to 30 g/day is considered appropriate.

Table 1 lists the desired weight gain in growth parameters in preterm LBW and term LBW babies.

Anthropometric parameter	Preterm LBW baby	Term LBW baby
Weight	15 g/day (if < 2000 g) 20 g/day (if > 2000 g)	20-30 g/day
Length	0.7-1.0 cm/week	2 cm/month
Occipito-frontal circumference	0.7-1.0 cm/week	0.5 cm/week

**Table 1:** Desired weight gain in growth parameters in preterm/LBW and term/LBW babies [2].

Adpated from: Dutta S, Sunil Sai Kishore M. Feeding low birth weight neonates. In: Gupte S (edn): RecentAdvances in Pediatrics(Special Vol 21: Neonatal and Pediatric Intensive Care). New Delhi: Jaypee 2011:366-373 [3].

Ideally, weight needs to be recorded twice a week and length and OFC once a week. The measurements should be plotted on reference postnatal growth charys.

**Biochemical Monitoring**

- Hematocrit weekly
- Serum sodium, calcium phosphorus, alkaline phosphatase and serum albumin fortnightly till discharge and at term except in babies on HMF when it should be a weekly monitoring.

**Discharge Criteria**

Criteria of discharge should be

- Reaching 34 weeks’ gestation and weight > 1400g
- Consistent weight gains for at least 3 consecutive days.

Ideally, after discharge, weight needs to be recorded twice a week and length and head circumference once a week [4]. The measurements should be plotted on reference postnatal growth charts.

**Ongoing and Future Research**

Like several unanswered questions in LBW infants as such, quite a few issues concerning nutrition in these babies remain to be investigated. These include

- Best time for starting, progression and frequency of oral feeding.
- Choice of milk in hospital and post-discharge
- Association between birth weight and feeding maturation in preterm infants.

- Relationship between feeding maturation and the rate of early weight gain and health problems later in life.
- Role of selected nutrient interactions and multivitamin-mineral supplements in improving pregnancy outcomes among undernourished pregnant women,
- Effect of food supplementation trials and its influence on the interrelation between maternal and infant outcomes over one or more reproductive cycle.

## Conclusions

Feeding of the LBW infants is a challenging front since quite a few of the issues remain to be sorted out through ongoing and future research. Notwithstanding controversies, this review presents a practical protocol for the nutrition of these infants in resource-limited settings. Also given is an approach to the growth and neuro-developmental monitoring during follow-up of the survivors. The areas warranting further research are listed.

## Take Home Messages

- Achieving immediate survival and optimal short-term and long-term growth and development should be the main goal of nutrition of LBW babies.
- Weight as well as maturity of the neonate should be taken into consideration in deciding the feeding approach.
- Human milk, at times supplemented with a human milk fortifier (HMF) or an appropriate formula, to meet the nutritional needs, should be the preferred option in event of oral/ enteral feeding.
- Trophic feeds i.e., minimal enteral nutrition (MEN) that should be initiated as soon as feasible as and when parenteral nutrition is given.
- Management of feed intolerance should be in place.
- Discharge parameters include reaching 34 weeks' gestation and weight > 1400g and consistent weight gain for at least 3 consecutive days.
- In order to identify growth failure, growth monitoring during and post-discharge is important.

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