Actual Nutrient Intakes of Extremely Low-Birthweight Infants

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Nutrient requirements have been described for the extremely low-birthweight infant (ELBW; less than 1,000 g birthweight) (1–3). These requirements serve as goals for the nutritional plan of care. Many factors may influence the ability to meet these nutritional goals. Complications of prematurity—including hyperglycemia, respiratory distress, sepsis, patent ductus arteriosus, and necrotizing enterocolitis—influence medical decisions about nutritional therapy. The initiation of nutritional therapy, type of nutrients provided (enteral or parenteral), amount of fluid to be given, and rate of nutrition advancement are all affected by the infant’s medical condition. It is assumed that eventually nutritional goals are met and growth begins. While studies have been done describing the growth of the very low-birthweight (VLBW) and ELBW infant, there is little information describing the actual nutrient intakes these infants receive.

Beginning in September 1994, routine nutrient intake and growth data were collected on all infants admitted to the Children’s Hospital of Iowa with birthweights of less than 1,300 g. Results of the first monitor interval, September 1994 to May 1995 (interval A), have been published previously (4). Data collection has continued to the present day to monitor changing trends in nutrition therapy and identify areas in which nutrition management of the VLBW infant may be improved. The effects of changes in nutritional practices can be evaluated by comparing monitor intervals over time. My purpose here is to describe changes in nutrient intakes and growth of infants born in interval A with those born from January to December 1997 (interval B). For the purposes of this chapter, only data from those infants of birthweight less than 1,000 g will be described.

DATA COLLECTION

A standard method of collecting nutrient intake and growth data was initiated in September 1994 and continues through the present time. All infants of birthweight less than 1,300 g and admitted to the University of Iowa Hospitals and Clinics spe-
TABLE 1. ELBW infants in interval A (9/94–5/95) vs. interval B (1/97–12/97) (median; range)

<table>
<thead>
<tr>
<th>Infant characteristics</th>
<th>Interval A</th>
<th>Interval B</th>
</tr>
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<tbody>
<tr>
<td>Number of infants</td>
<td>35</td>
<td>51</td>
</tr>
<tr>
<td>Birthweight (g)</td>
<td>790; 427–1000</td>
<td>736; 349–983</td>
</tr>
<tr>
<td>Gestational age (weeks)</td>
<td>26; 23–31</td>
<td>26; 22–30</td>
</tr>
<tr>
<td>SGA/AGA/LGA</td>
<td>26% / 74% / 0%</td>
<td>36% / 64% / 0%</td>
</tr>
<tr>
<td>Breast milk/combo/for</td>
<td>44% / 27% / 29%</td>
<td>31% / 47% / 21%</td>
</tr>
<tr>
<td>Days to regain bw (d)</td>
<td>13; 3–28</td>
<td>13; 3–23</td>
</tr>
<tr>
<td>Days to first FE (d)</td>
<td>4; 1–18</td>
<td>3; 0–7</td>
</tr>
<tr>
<td>Days to start of HM fortification (d)</td>
<td>24; 11–51</td>
<td>26; 11–73</td>
</tr>
<tr>
<td>Days to all FE (d)</td>
<td>28; 14–70</td>
<td>34; 11–92</td>
</tr>
<tr>
<td>Length of stay (d)</td>
<td>89; 41–203</td>
<td>78; 31–221</td>
</tr>
<tr>
<td>Discharge weight (g)</td>
<td>2060; 1250–3170</td>
<td>2240; 950–4530</td>
</tr>
</tbody>
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AGA = appropriate weight for gestational age; LGA = large for gestational age; SGA = small for gestational age.
mature human milk—that is, 67 kcal/dl and 1 g protein/dl. Actual weight of infants is recorded every seventh day of life. For those infants who are weighed more than once in the 24-hour period, the first recorded weight of the day is used.

DATA CALCULATIONS

Because nutritional goals and anticipated weight gains change as the infant matures, the data are divided into four feeding periods: the parenteral period (age 0 to 14 days), the transitional period (age 15 to 35 days), and the early and late feeding periods (age 36 to 56 days and 57 days to term adjusted age, respectively). Nutrient intakes calculated during a feeding period are averaged for that period (e.g., intakes calculated at age 21 days, 28 days, and 35 days are averaged to determine the mean nutrient intake during the transitional period). Table 2 compares the nutrient intakes for fluid, energy, and protein by feeding period in interval A versus interval B. Weight gains are calculated by subtracting weight at the beginning of the period from the weight at the end of the period and dividing by number of days in the period. Weight gains (g/kd·d) are calculated by dividing this number by the average weight during the feeding period. Table 3 compares the weight gain (g/d and g/kg·d) in intervals A and B to fetal growth rate at the same gestation. Fetal growth for the same feeding periods were calculated from 50th centile weights, using 26 weeks of gestation as age 0 days, 28 weeks of gestation as age 7 days, and so on (6).

<table>
<thead>
<tr>
<th>TABLE 2. Nutrient intakes by feeding period for ELBW infants, interval A (9/94–5/95) vs. interval B (1/97–12/97) (mean ± SD)</th>
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</thead>
<tbody>
<tr>
<td>Feeding interval</td>
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<tr>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Parenteral period (age 0–14 days)</strong></td>
</tr>
<tr>
<td>Number of infants</td>
</tr>
<tr>
<td>Fluid intake (ml/kg)</td>
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<tr>
<td>Energy intake (kJ/kg)</td>
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<tr>
<td>(kcal/kg)</td>
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<tr>
<td>Protein intake (g/kg)</td>
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<tr>
<td><strong>Transitional period (age 15–35 days)</strong></td>
</tr>
<tr>
<td>Number of infants</td>
</tr>
<tr>
<td>Fluid intake (ml/kg)</td>
</tr>
<tr>
<td>Energy intake (kJ/kg)</td>
</tr>
<tr>
<td>(kcal/kg)</td>
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<tr>
<td>Protein intake (g/kg)</td>
</tr>
<tr>
<td><strong>Early enteral period (age 36–56 days)</strong></td>
</tr>
<tr>
<td>Number of infants</td>
</tr>
<tr>
<td>Fluid intake (ml/kg)</td>
</tr>
<tr>
<td>Energy intake (kJ/kg)</td>
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<tr>
<td>(kcal/kg)</td>
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<tr>
<td>Protein intake (g/kg)</td>
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<tr>
<td><strong>Late enteral period (age 57 days to term)</strong></td>
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<tr>
<td>Number of infants</td>
</tr>
<tr>
<td>Fluid intake (ml/kg)</td>
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<tr>
<td>Energy intake (kJ/kg)</td>
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<tr>
<td>(kcal/kg)</td>
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<tr>
<td>Protein intake (g/kg)</td>
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</tbody>
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TABLE 3. Weight gain of ELBW infants by feeding period, interval A (9/94–5/95) vs. interval B (1/97–12/97) (mean ± SD)

<table>
<thead>
<tr>
<th>Feeding interval</th>
<th>Interval A</th>
<th>Interval B</th>
<th>Fetal growth rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parenteral period (age 0–14 days)</td>
<td>Weight gain (g/d)</td>
<td>1.9 ± 4.7</td>
<td>3.1 ± 4.7</td>
</tr>
<tr>
<td></td>
<td>Weight gain (g/kg·d)</td>
<td>2.1 ± 5.6</td>
<td>4.1 ± 6.6</td>
</tr>
<tr>
<td>Transitional period (age 15–35 days)</td>
<td>Weight gain (g/d)</td>
<td>12.2 ± 4.7</td>
<td>15.7 ± 5.8</td>
</tr>
<tr>
<td></td>
<td>Weight gain (g/kg·d)</td>
<td>13.1 ± 4.5</td>
<td>16.5 ± 4.3</td>
</tr>
<tr>
<td>Early enteral period (age 36–56 days)</td>
<td>Weight gain (g/d)</td>
<td>16.8 ± 5.7</td>
<td>21.3 ± 7.4</td>
</tr>
<tr>
<td></td>
<td>Weight gain (g/kg·d)</td>
<td>13.5 ± 4.3</td>
<td>16.3 ± 4.2</td>
</tr>
<tr>
<td>Late enteral period (age 57 days to term)</td>
<td>Weight gain (g/d)</td>
<td>20.3 ± 6.2</td>
<td>26.9 ± 7.8</td>
</tr>
<tr>
<td></td>
<td>Weight gain (g/kg·d)</td>
<td>12.0 ± 4.0</td>
<td>14.3 ± 3.6</td>
</tr>
</tbody>
</table>

RESULTS

General Characteristics

The median gestational age of ELBW infants was similar in both monitor intervals, although a higher percentage of SGA infants in interval B made the median birthweight lower than interval A. More than 70% of ELBW infants in both monitor intervals began with breast milk feeds. Despite the extended length of stay, nearly 40% of the infants continued on breast milk feeds throughout their hospital stay. Minimal changes between interval A and interval B were seen in days to regain birthweight, age to initiate enteral feeds or human milk fortifier, and age when intravenous fluids were first discontinued (full enteral feeds). Despite minimal changes in the age when enteral feeds were initiated, the range was substantially smaller, indicating a more consistent use of early enteral feeds. Length of stay in the special-care nurseries declined in interval B, showing the increased number of transfers to other hospitals or nursing units (62% in interval B versus 49% in interval A) and decreased number of discharges to home (38% in interval B versus 51% in interval A). Despite the shorter length of stay and lower median birthweight, the median discharge weight in interval B was 180 g higher than the median discharge weight in interval A.

Nutrient Intakes

Fluid restriction remains a standard component of medical management for infants at risk for bronchopulmonary dysplasia (BPD). Fluid intake varied minimally from interval A to interval B. During the early enteral feeding period, approximately 60% of infants born weighing less than 750 g had average fluid intakes ≤135 ml/kg. Fifty percent of infants born weighing 750 to 1,000 g had mean fluid intakes of ≤135 ml/kg in the same feeding period. In response to the need for fluid restriction, concentrated feeds were often used, with 47% of infants in interval A and 63% of infants in interval B receiving concentrated formulas or fortified human milk.
Energy

Energy intake during the parenteral period overestimated actual energy intakes during the period, as the days of measurement were age 7 and 14 days. Improving energy intakes from interval A to interval B were seen in the parenteral period and late enteral feeding period. In the former, increased energy intake probably reflected the use of higher concentrations of dextrose and amino acid solutions in parenteral feeding. Increased use of concentrated feeds and the extended use of preterm formula and human milk fortifiers in infants weighing 2,000 to 3,000 g increased energy intake in the late enteral feeding period.

Protein

Protein intake may be underestimated in both intervals A and B owing to the high percentage of breast milk-fed infants and the use of mature human milk protein content for nutrient intake calculations. In addition, actual mean protein intake in interval B was underestimated as some of the infants were involved in a protein supplementation study. Because the study protocol is double blind, it is unknown which infants received protein supplementation. Therefore this protein intake could not be included in the nutrient intake calculations. However, a review of protein intakes in interval B versus interval A showed a trend toward improved protein intakes in all but the early enteral feeding period. Protein intakes in interval B were increased by using higher amino acid concentrations in parenteral nutrition and by extending the use of preterm formulas and human milk fortifiers for infants weighing 2,000 to 3,000 g.

Growth

The weight gain of infants in interval B surpassed that of infants in interval A in all feeding periods both in g/day and in g/kg-d. When compared with fetal growth calculated from the 50th centile weight for gestational age starting at 26 weeks of gestation, infants in intervals A appeared to exceed fetal growth (g/kg·d) in the late enteral period, whereas those in interval B appeared to exceed fetal growth in both the early and late enteral periods (6). Early growth failure results in a smaller denominator in the g/kg·d equation and thereby exaggerates weight gains in infants of less than the appropriate weight for age. When growth rates were converted to total weight gain (g/d), the growth of infants in both monitor intervals was below fetal growth rate throughout their hospital stay. Figure 1 shows the mean weight of infants in intervals A and B compared with the 50th centile weight of infants at similar gestational ages. This figure demonstrates the increasing growth deficit occurring in ELBW infants throughout the period of hospital admission.

DISCUSSION

Results of nutrition monitoring completed in September 1994 to May 1995 showed a deficit in both energy and protein intake of VLBW infants throughout their
hospital stay (4). Subsequently, nutrition interventions were initiated to improve awareness of nutrition deficits and to modify nutrition practices in the special-care nurseries at the University of Iowa Hospitals and Clinics. Interventions included routine review of nutrition monitoring results with health care team members, increased use of high-nutrient-density parenteral nutrition solutions through percutaneous central catheters, extended use of premature formulas and human milk fortifiers in infants weighing 2,000 to 3,000 g, and development of nutrition guidelines and references for medical residents and nurse practitioners. In addition, a routine electrolyte monitoring and supplementation protocol was established and a double-blind randomized controlled trial of protein supplementation was initiated. As a result of these interventions, nutrition monitoring completed in January 1997 to December 1997 showed increases in energy and protein intake as well as improved weight gains and fewer days in a level III nursery.

Despite these improvements, infants continue to fall below estimated goals in energy and protein intakes as well as in weight gain. It has been estimated that preterm infants require nutrient intakes of 110 kcal/kg-d for growth (7). During interval B, this goal was achieved only in the late enteral interval. Barriers to achieving energy
goals include fluid restrictions and slow advancements in enteral feeds to adjust for growth. A recent review of 10 ELBW infants on full enteral feeds found the mean number of days between enteral feeding advancement was 3.8. Nine of the 10 infants had at least one feeding period when enteral feeds were held at the same volume for ≥7 days.

Estimated protein goals of ELBW infants are 4 g/kg·d using the factorial method (3). As the infants grow, protein requirements decline but still remain at 3.5 g/kg in infants weighing 1,500 to 2,000 g. Despite improvements in protein intakes from interval A to B, protein intake remained below goals throughout special-care nursery admission. Potential causes for this protein deficit included fluid restrictions and the use of concentrated feeds made from the addition of term formula concentrates. The predominant reason for reduced protein intakes is likely to be the protein energy ratio of current preterm infants feeds. Although it is estimated that infants weighing less than 1,000 g require a protein-to-energy ratio of 3.6 g/100 kcal, preterm infant formulas contain at best 3.0 g/100 kcal, and fortified human milk is even lower.

Wilson et al. described improved growth and earlier hospital discharge in 64 VLBW infants fed an aggressive nutrition regimen (8). Berry et al. showed a positive correlation between energy and protein intakes and growth in 109 ELBW infants (9). In addition, they found a negative correlation between birthweight ratio and growth. Improved growth rate from interval A to interval B may be due to the higher percentage of SGA infants in interval B but also is probably related to improvements in energy and protein intake. Increased intake of protein in particular may have contributed to the increased growth. Kashyap and Heird have shown a relation between increasing protein intakes and growth (10). Infants meeting estimated protein requirements in their studies met or exceeded fetal growth rates. The greatest improvement in energy and protein intake occurred in the parenteral period, whereas the biggest improvements in weight gains occurred in the transitional period. It is reasonable to assume that early adequate nutrition may affect growth and nutritional status well beyond the first weeks of life.

Despite improvements in weight gain, growth of ELBW infants remained significantly below fetal growth. By the late enteral interval, weight gain rates (g/kg·d) exceeded those of the fetus; however, total weight gain (g/d) continued below fetal growth. Therefore a weight deficit continued to accrue throughout the period in the hospital. The mean weight of infants in interval B at 36 weeks of gestation-adjusted age was 1,036 g less than the weight of a 36-week-gestation fetus growing at the 50th centile. Because interval B had a large number of SGA infants, the infants started with a weight deficit. However, the weight deficit at birth was only 164 g, substantially lower than the weight deficit 10 weeks later.

CONCLUSION
Extremely low-birthweight infants remain at high risk of nutritional deficits. Although improvements in nutrient intakes, particularly protein, were shown to improve growth rate in this study, ELBW infants continued to fall behind fetal growth
curves throughout their hospital stay. Various factors in prematurity may influence growth. Berry et al. found a negative correlation between dexamethasone use and growth and between respiratory support duration and growth (9). The multiple medical challenges facing the ELBW infant may make it impossible to achieve fetal growth outside the womb. However, every effort should be made to improve nutrition therapy, achieve nutrition goals, and thereby improve nutritional status and growth of these infants.

REFERENCES


DISCUSSION

Prof. Lucas: You posed so many important practical questions that we could have spent the whole rest of the day addressing them. These are immensely important matters for clinical practice. It seems that the failure to meet the infant’s needs is caused by two main factors. One is not prescribing enough, and the other is not giving what you actually prescribe. It is the latter I want to discuss. We recommend that when babies are not growing well, a neonatologist should record the prescribed protein and energy intake, and not the achieved protein and energy intake, and they are often radically different. One of the reasons for that difference is that when feeds are discarded, because of gastric aspirate or distention, they are not replaced, or when an intravenous infusion tissue ceases for a couple of hours because the resident is busy, the amount lost is not replaced. What is the solution to that? Should we recalculate after a missed feed so that we give an increased amount? Should we overprescribe deliberately to account for likely losses? What is your policy for dealing with that?

Ms. Carlson: Our policy is not well established. Perhaps we should set our goals a little bit higher with the understanding that we may not provide the full amount. Then I think we need to be more attentive at ensuring that if feeds are withheld, they are withheld for a reason. Another thing that I did not bring up but which I think is important is that often feeds are not advanced as the children grow. The residents feel that if the baby is continuing to gain weight, why should the feeds be increased. We need to be rather more proactive with advancing feeds as the babies grow.
**Prof. Moro:** You said that you are giving electrolyte supplementation orally? Why do you give oral electrolytes, rather than intravenously? Do you measure the osmolality of the solution?

**Ms. Carlson:** I was referring to electrolyte supplementation given after the children are no longer receiving intravenous fluids. We find that many preterm infants on full enteral feedings have hyponatremia or hypokalemia and require some electrolyte supplementation. I agree that it is important to consider the effect on osmolality, because oral electrolyte solutions are certainly hyperosmolar. We are very careful to give small amounts with many feeds rather than large amounts with just a single feed. We find the babies tolerate electrolyte supplements well.

**Prof. Ziegler:** For clarification, Ms. Carlson calls it supplementation when it is given enterally. While the baby is on parenteral nutrition, the electrolytes are of course adjusted to maintain normal serum values. The criteria for when supplementation is necessary are not well established. Sometimes we supplement when the serum sodium reaches 130 mmol/l, and sometimes only when it is way below 130. A high proportion of the babies who require electrolyte supplementation are receiving diuretics and that may be the main reason. Another important reason is that our feeds, whether human milk with fortifier or formula, are all low in sodium.

**Dr. Rashwan:** Were these babies receiving multivitamins or other oral supplements?

**Ms. Carlson:** We did not give additional vitamin supplementation to infants fed fortified human milk or preterm formula, though babies on fortified breast milk did receive iron supplementation.

**Dr. Sedaghatian:** We also use oral electrolytes and sometimes bicarbonate when the infants are on enteral feeding. I think this is necessary. But I was amazed by the amount of fluid you give to babies of less than 1,000 g sometimes up to 300 or 400 ml/kg body weight. Is that correct?

**Ms. Carlson:** There certainly were babies who received substantially higher fluid intakes than are generally accepted as the norm. But remember that those intakes of 300 ml/kg were given during the first 3 to 4 days of life, before the babies developed a satisfactory skin barrier. By day 7, our fluid intake was quite low, which probably reflected our concern about preventing patent ductus arteriosus.

**Dr. Sedaghatian:** Do you think we should try to achieve intrauterine growth rates at any cost? Maybe we should be content with lesser amounts of growth and give more attention to other factors in their care. In the past, it has been accepted that babies grow slowly under these conditions, and neurodevelopmental outcome has been satisfactory.

**Ms. Carlson:** I don’t think we know what the potential of our babies is for growth. It may be unreasonable to expect a 25-week-gestation infant ever to grow at the intrauterine rate outside its mother. But from the data we have collected we know that our nutrient intakes did not even meet our goals. Although many babies may have a good neurological outcome despite poor growth, is it not possible that we could enhance the outcome by providing better nutrition?

**Dr. Georgieff:** Your study raises the question of the role of “nutrition support service police” in an intensive-care nursery, particularly where you have residents prescribing the daily nutrient intakes. Have you had a chance to compare intakes and compliance in a prenutrition support and a postnutrition support era? Do we do better when we have somebody coming round once a week to check on intakes, particularly when the service tends to be pulmonary oriented?

**Ms. Carlson:** There has been a dietitian at the University of Iowa Hospital Special Care Nurseries since long before I came, so it’s hard for us to do a pre- and postevaluation. But I’m
hoping to show that with more attention to methods of feeding there will be improved intakes and improved growth.

Dr. Georgieff: In our institution this has been looked at in the adult ICU with a nutrition support service. There were substantial cost savings to the hospital such that the administration now makes nutrition support consultations mandatory.

Ms. Carlson: There are institutions that don’t have dietitians actively involved in the special-care nurseries, and those might be the sort of place to do that kind of evaluation in neonates.

Dr. Micheli: Your postnatal protein intake figures were similar to the ones showed by Prof. Heird and by myself yesterday. I do wonder, though, why we are depriving these fetuses of amino acids and protein during the first 14 days. Their intakes during this period are far below what they would have received in utero.

Ms. Carlson: I agree that by day 14 we still aren’t providing the protein goal that we think preterm infants need. I’m not certain that I can identify all the reasons. In the first week or so, babies who are on parenteral nutrition may become septic so the catheter is removed and they are placed on dextrose, electrolyte solutions; we then lose 24 hours of intravenous amino acids while we wait for the next bag of TPN to come up. The low protein intakes that you see in the later intervals may be related to the low protein content of preterm formula and fortified breast milk. Many of our babies start on breast milk feeds, but we don’t start fortifiers until the babies are about a month old. Even after increasing the amino acids in our parenteral solutions we may not be able to achieve our protein guidelines.

Dr. Micheli: But during this early adaptive phase we all prescribe protein intakes that are much lower than the supply that would be given through the placenta at the same gestational age. I don’t know why.

Ms. Carlson: Maybe as we feel more comfortable with managing ELBW infants, we’ll feel more comfortable about giving protein early.

Prof. Lucas: In our study comparing term formula with preterm formula, we randomly assigned those diets for a month and saw a major difference in neurodevelopmental outcome. If we just assume for one moment that this could be something to do with protein intake for essential tissue growth like brain growth, we are looking at 0.6 g/kg-d difference in protein intake between the two groups, yet we prescribe deficits of way over 0.6 g/kg-d of protein intake during the first month. I think Dr. Micheli has raised a critically important point. I can’t help feeling that in 30 years’ time, we will look back on this period of protein restriction in the early life of preterm infants as an extraordinary folly of late-twentieth-century neonatal practice.

Ms. Carlson: I completely agree.

Prof. Heird: It seems clear now that babies who are getting less than 1 g/kg-d of amino acids are in negative balance, and they are in approximate balance at 1 g/kg. Thus even if they receive 1 g/kg-d of protein over the first two weeks, which they may not, by the end of that time they will already have incurred a protein deficit of around 52 g compared with what they should have received in utero, and this is going to take a while to make up.

Prof. Ziegler: If we look back to 8 years ago, we would probably see intakes in the first week of life averaging less than 1 g/kg. It used to be standard practice not to provide TPN in the first 4 or 5 days, and then to start at 0.5 g/kg. Nobody knows where this came from, but it was standard practice. Now we are starting with 1.5 g on the first day of life. I think we are doing much better than we did only a few years ago, but I agree with you—we are not doing well enough.

Dr. Rigo: I’d like to ask about fluid restriction. You said that there was a fluid restriction policy in your unit aimed at preventing bronchopulmonary dysplasia. But the incidence of
BPD seems to be decreasing in most units, even in ELBW infants, with or without a policy of fluid restriction. It also seemed from your results that you were not increasing the fluid intake the first month of life, even in babies without BPD. Do you continue with fluid restriction right to the end of the stay in the neonatal unit, or do you have two populations that you can analyze separately—babies with fluid restriction and babies without fluid restriction?

Ms. Carlson: There are some babies without significant lung disease who receive more fluids. However, our unit policy may represent a particular way of managing lung disease—the residents believe that fluid restriction is good for preventing bronchopulmonary dysplasia, and many babies have fluid restrictions, even those who would probably tolerate more fluids. It is clear that much higher fluid volumes are given in some other units. It would be interesting to compare outcomes between units that give low and high fluid volumes with respect to BPD.

Prof. Cooper: As far as I'm aware, the data relating increased fluids to bronchopulmonary dysplasia and persistent ductus arteriosus relate to the early neonatal period. It's not scientific to extrapolate that beyond the first month or to the child who's already got established lung disease. Do you know of any data to support this policy? Otherwise, it would sound like a good subject for a randomized controlled study, since one could postulate the opposite—better nutrition and better growth might actually improve BPD regardless of the fluid intake.

Prof. Ziegler: Please don’t hold our neonatal dietitian responsible for the policies of some neonatologists! Some of our neonatologists strongly believe in fluid restriction. That’s the simple explanation for those low fluid volumes.

Prof. Lucas: We have monitored fluid intake of premature babies once they go home. Within 4 weeks of going home, a significant proportion of premature babies are spontaneously consuming between 250 and 350 ml/kg. I think we have probably been far too restrictive of volume in the well-growing baby. We have missed an opportunity of increasing dietary intake by manipulating volume.

Dr. Atkinson: Did you do any length measurements?

Ms. Carlson: No, we didn’t. We don’t feel very comfortable with the accuracy of length measurements within our institution in our ELBW infants, so we did not feel that those measurements would provide us with accurate data.

Dr. Atkinson: In our neonatal unit, our dietitian does them once a week. My second question is relating to your oral supplements. You did not list phosphorus supplements. I wondered whether you have much hypophosphatemia in these tiny babies, especially the ones on steroids.

Ms. Carlson: Not that we’ve noticed. We occasionally give calcium and phosphorus supplementation, but always together. This would be for babies who are at risk of rickets of prematurity. We concentrate our preterm formula by adding term formula concentrates, which not only dilutes protein but also dilutes calcium and phosphorus intake. Often these infants require additional calcium and phosphorus supplements to meet their needs for bone mineralization.

Dr. Rashwan: We have no dietitian in our hospital, in common with most of the Middle East area. I want to ask you about the nature of your work. Does your role start before oral feeding begins or after? And is your collaboration with the neonatologists on a daily basis? Do you plan the regimen with the neonatologists?

Ms. Carlson: I am involved with the infants from their admission into the neonatal intensive-care unit. Some institutions have a pharmacist who deals with the parenteral feeding and a dietitian who deals with the enteral feeds. I work with both. In our neonatal intensive-care unit, I help the staff write the parenteral prescriptions daily and recommend changes in enteral feeding regimens. In our intermediate unit, my involvement is less frequent, but I try to see
what the babies are receiving on a daily basis. If I see any baby whose intake is far below our goal, I interact with the residents to get changes made.

Prof. Ziegler: The issue of what the dietitian is allowed to do and what neonatologists reserve for themselves is an interesting one. In our case the neonatologist determines the total fluid volume, the age at which feeding is started, and when feeding is withheld. Practically everything else is left to the dietitian, and because of that, Ms. Carlson has had a considerable impact on, for example, how much amino acids are given from the beginning. So in our case the dietitian has almost total autonomy in some areas, while in other areas she has no say at all.

Dr. Rashwan: Why is your role limited to the ICU? Surely it is also very important to be involved after discharge?

Ms. Carlson: As the dietitian, I am involved with the infants in the step-down nursery and after discharge. So we do try to continue to maintain optimum nutrition throughout those periods as well.

Prof. Polberger: Your title was “actual nutrient intakes,” but it seems that you did not do any milk analyses. You estimated the human milk energy and protein to be the values accepted for mature human milk—that is, 67 kcal and 1 g protein per deciliter. But weren’t you using mother’s own milk, so shouldn’t you have used data for preterm milk?

Ms. Carlson: We don’t do nutrient analysis of the breast milk, so we don’t really know what it contains. It’s also difficult to identify when a baby is getting preterm milk or mature milk in our unit, so overall I felt it was better to underestimate than overestimate the nutrient content by using the mature milk value.

Prof. Devlieger: In our unit, we have designed with the help of a pharmacist a fixed standard TPN solution with different degrees of dilution, depending on the fluid tolerance of the baby. We are able to reach the required intake of energy and protein within 5 days. What is the role of the pharmacist in your parenteral feeding procedure?

Ms. Carlson: At our institution, we do not have a pharmacist who is actively involved in our neonatal intensive-care unit. Therefore I assist with parenteral nutrition orders. In our pediatric intensive-care unit, there is a pharmacist involved in helping to determine appropriate parenteral regimens, but that does not occur in our neonatal ICU.

Dr. Chessex: I’d like to return to the fundamental question that has been raised these last days by Prof. Ziegler, Dr. Micheli, and Prof. Lucas: Why aren’t we following the recommendations? One reason may be that people outside this room don’t believe it is important. This may be because there is not enough solid information showing that it is important. When Dr. Morley’s studies are published it will perhaps be easier for people to believe in the importance of nutrition. If you see a brain echo with a large bleed, you have no difficulty in accepting that this may cause long-term problems, but when you hear talk about negative nitrogen balance, it is more difficult to make the connection. We need more solid evidence, and we are going slowly in that direction.

Prof. Lucas: I agree with that, but it is possibly a little unfair. There is a huge amount of accumulated data on malnutrition and adverse outcome. The major problem is the failure to communicate it rather than the failure to generate it. Obviously, we need more clinical trials, but making babies malnourished does not make sense on the basis of the information that we’ve already got.