Diet and renal function in malnutrition

Summary of presentation

Supplementary suckling (SS) has revolutionised management of young, malnourished infants.

Water balance in young, malnourished infants

Water is an important nutrient, required to 'carry' excess electrolytes and urea (collectively called solute) into the urine. If there is not enough water, the solute builds up in the body. Much water is lost in the breath and through the skin - the greater this insensible loss, the less water there is available to excrete the solute and the greater the water requirement. Where renal concentrating capacity is impaired, water intake becomes even more critical.

In normal infants, fever or high respiratory rate leads to increased water loss. Presence in a hot climate increases water loss, and a dry climate can lead to very rapid water loss.

Small babies are particularly vulnerable to pure water dehydration (not salt and water dehydration) because their surface area to volume is much greater than in heavier children and their respiratory rate is higher - this leads to increased evaporative loss.

In addition, malnourished infants are particularly prone to water deprivation because they have a high surface area: volume ratio, may have diarrhoeal losses (which gives both salt and water loss) and cannot concentrate their urine (see renal function in severe malnutrition).

Malnourished children may be protected at home because they are often given thin watery foods, they have a low metabolic rate and so generate less heat that has to be lost. But when they get to hospital this all suddenly changes!

Evaporative water loss

Heat is lost, or 'excreted', by the body through water evaporation from the body surface. Relatively large amounts of water are required to excrete heat - 1g of water is required to lose or dissipate 0.54 kcal. Thus if 100ml/kg are lost, this will consume 54 kcal/kg. Skin lesions, which lose water in a dry climate, require extra heat generation in the body to avoid hypothermia.

Evaporative losses are at least 50 ml/kg in a normal child of 4 kg (see figure 1), and are higher in smaller infants. In investigations in Tchad, malnourished children had a water turnover of one third of body water per day (about 240 ml/kg/d) when the temperature was 43 degrees celsius and 15% humidity - 7 of 22 children in the TFC had hyperosmolar syndrome. 'Fits' were often recorded as a cause of death.
Renal function in severe malnutrition

Normal infants can achieve a renal concentration of about 700 mOsm/l, malnourished infants have a mean maximum renal concentrating ability of about 450 mOsm/l and some cannot concentrate their urine at all.

The renal solute load (renal osmolarity required to maintain water balance on a given intake) of diets vary greatly (see figure 2). Human breast milk has a very low renal solute load - no other diet that is satisfactory for growth comes close to breast-milk.

Using F75, small differences in intake can make a big difference to the ability to excrete solute. The higher the intake of F75, the more water there is available to excrete the solute and the lower the renal osmolarity. However if a child is not achieving an intake of 100 kcal/kg/d (i.e. 130 ml/kg/d), then he will be deficient in water unless extra water is given.

How does this influence formula choice?

Figures 3 and 4 demonstrate the effect of dilution of F100 on renal osmolarity at various dietary energy intakes. Figure 3 reflects the urinary osmolarity that needs to be achieved at various non-renal water losses to prevent hyperosmolar syndrome, whilst taking F100. Similarly figure 4 demonstrates the urinary osmolarity, given the same non-renal losses, when taking F100-diluted (75 kcal/100 ml).

It is dangerous to give ORS, which has a renal solute load of about 200 mOsm/l, to replace evaporative losses in hot dry climates.
These figures demonstrate that at a non-renal loss of 50ml/kg/d, with an intake of 100 kcal/kg/d (100ml/kg) from F100, the urine must be concentrated to about 420mOsm/l. With an intake of 100kcal/kg/d (130ml/kg) of F100-d, however, urine must only be concentrated to 230mOsm/kg to maintain fluid balance. With F100-d, the same renal stress as with F100 only occurs when insensible losses reach over 80 ml/kg/d.

**How does this influence practice?**

Up to about six months of age, birth weight is the dominant factor determining current weight, and is related to current weight up until about 18 months of age. Malnutrition in infants less than six months is predominantly due to antenatal malnutrition or prematurity - this is different from those who have become malnourished post-natally. Malnutrition in breastfed infants is almost always the result of inadequate feeding practice.

With proper management, however, breastfeeding can become perfectly adequate for the child to grow normally, and for the malnourished child to have catch-up growth on breast milk alone. The supplemental suckling technique - developed from well-established relactation methods - has truly revolutionised management of the breastfed severely malnourished child.

**Experiences in Burundi**

In a trial of the supplementary suckling technique (SS) in Burundi in 2000, 57 malnourished infants were treated with breastmilk and SS, using F100 diluted to 75kcal/100ml. The mean admission weight was 2.7kg. Rate of weight gain was 14.6 g/kg/d and length of stay was 28 days. Overall, 12.9% abandoned the programme, and 10.5% died (six infants). Four of those who died weighed 2kg or lower - infants less than 2kg have high mortality anywhere.

Whatever supplementary formula is started with a young infant, it makes sense to continue - most infants having the supplemental suckling technique do not like to change the supplementing diet. F75 was designed for
stabilisation, rather than rehabilitation and since most malnourished infants do not need a stabilisation phase, F75 is not the formula of choice in this group.

Infant formula can be safely used with young malnourished infants. However in the interests of consistency, simplicity and the risk of undermining breastfeeding by introducing supplies of infant formula, it is not recommended as the product of choice. Given the limitations of F75 and infant formula, F100-d is very much safer in any situation where there are high non-renal water losses, as in the case of the small malnourished infant. For this reason, full-strength F100 should not be used in infants under six months.

F100-d, or a return to the phase 1 diet, should also be used in older children with fever, high respiratory rates or in dry environments. Where a unit is short-staffed, which is usual, it is unsafe to rely on a diet being automatically changed when a small child has a fever or tachopnoea.

For older children (over 6 months), at an intake of 150kcal/kg/d, which is common during catch-up weight gain, F100 is perfectly safe provided that the insensible losses do not exceed about 80ml/kg/d. If a child loses appetite and refuses some feed, so that only 80kcal/kg/d are taken from the diet, then extra water should to be given - particularly if the loss of appetite is associated with a fever.

Diets of over 100kcal/100ml are likely to give hyperosmolar syndrome and should not be used.

**Key issues**

1. Water is an important nutrient, but can often be limiting
2. Fever, and high respiratory rates can increase insensible water loss
3. Small, malnourished infants are particularly vulnerable to water deprivation
4. Evaporative water loss in young infants is significant, especially in hot, dry climates
5. Renal concentrating ability is impaired in the malnourished
6. The renal solute load of the diet is critical
7. Catch-up growth in the malnourished can be achieved on breastmilk alone
8. Supplementary suckling (SS) has revolutionised management of young, malnourished infants
   - Expressed breastmilk or F100 diluted (0.75kcal/ml) is recommended with SS
   - F75 or infant formula are safe to use but have significant limitations
   - Full strength F100 (1 kcal/ml) should not be used in infants less than 6 months or under 4kg
   - Concentrations higher than 1kcal/ml should not be used
9. All malnourished children in desert (dry) areas should be treated with F100 diluted.

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1. Presentation by Professor Mike Golden, Renal function in malnutrition, Core group meeting, Geneva, 16-17th April, 2003

2. Outline of hyperosmolar syndrome


4. ME Corbett. Severe malnutrition in the infant less than 6 months - use of the supplemental suckling technique. MSc thesis, University of Aberdeen 1998