MEDICAL PRACTICE

Contemporary Themes

Towards cheaper intravenous nutrition

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During these times of financial restraint it is beholden on all clinicians critically to evaluate their therapeutic methods with regard to cost effectiveness. Take, for example, intravenous nutrition. Can it be justified in terms of clinical benefit and, if so, might not the costs be reduced without compromising the effectiveness of the regimens employed?

Intravenous feeding is expensive. The solutions and additives alone cost between £50 and £70 a day, which amounts to almost £100 000 in any hospital feeding six patients at any one time over a year. Furthermore, this expenditure does not include the material costs of administering these solutions or the substantial labour costs incurred by medical, nursing, and pharmacy staff. Clearly, if the number of patients receiving intravenous nutrition could be reduced then substantial savings in hospital expenditure could be achieved.

Who needs intravenous nutrition?

In which patients can intravenous nutrition be justified? It is of proved value in the management of enterocutaneous fistulas and in the early management of patients with the so called short bowel syndrome.² There is good clinical evidence to support its routine use in low birthweight infants with respiratory distress syndrome³ and that it promotes recovery from an episode of acute renal failure.⁴ Somewhat surprisingly, however, there is remarkably little evidence from controlled clinical trials that mortality or morbidity is significantly reduced by intravenous nutrition in the many other conditions for which it is often recommended. The case for preoperative intravenous nutrition, for instance, remains unclear despite occasional encouraging reports.^{5,6} Routine intravenous nutrition after major abdominal surgery is frequently considered beneficial, but proof of this is lacking.⁷ Certainly there are isolated reports of clinical benefit, but these remain few and far between.^{8,9} Intravenous nutrition is often advocated in the management of inflammatory bowel disease but controlled clinical

studies have failed to show any convincing clinical advantage.^{10,11} Some clinicians use intravenous nutrition as a supplement in patients considered to have an inadequate oral intake, and in many of these the duration of intravenous nutrition may be only a few days.¹² There is little evidence to support its use for less than seven to 10 days, or indeed as a supplement to other nutrition.¹² Finally, intravenous nutrition is often recommended in patients with cancer on the basis that it will either improve the response to chemotherapy or radiotherapy or reduce the side effects associated with these treatments.¹³ Although some of these reports support this view, they do not provide sufficient justification for the routine adoption of intravenous nutrition in all these patients. Admittedly, most of these studies show a return towards normal of various nutritional markers, and, as malnutrition itself is associated with an increase in mortality and morbidity,¹⁴ it is often inferred that restoration to normal of the nutritional state must be beneficial. Although this assumption is probably correct, it would be wrong to conclude that intravenous nutrition, or any other form of nutritional support, is indicated on the basis of abnormal laboratory or anthropometric data alone.

Can, then, intravenous nutrition be justified where clinical benefit remains unproved? The objective assessment of clinical benefit is notoriously difficult and consequently the absence of statistical proof does not necessarily imply that no clinical gain has occurred. Indeed, it is noteworthy that no clinical trial has ever shown any significant disadvantage as a direct result of intravenous nutrition, though no study has specifically addressed itself to this question. Furthermore, it must be remembered that intravenous nutrition is an adjunct to definitive treatment and not always (unless bowel rest is considered a treatment) itself therapeutic. Hence the concept of temporary or permanent intestinal failure advocated by Professor Miles Irving as a guide to the necessity for intravenous nutrition is very valuable. It emphasises that intravenous nutrition may be thought of as a substitute for the gastrointestinal tract in much the same way as dialysis machines are used in renal failure. Considered in this way, it can be seen that the clinical value of intravenous nutrition often lies in the fact that it prevents further deterioration in the patient's condition, not that it necessarily produces faster healing or specifically reduces complications.

Reducing the costs**HOW MUCH PROTEIN AND ENERGY?**

Given that intravenous nutrition can be justified in patients with intestinal failure, but in very few others, what can be done to keep costs to a minimum? Firstly, attempts should be made to reduce waste. Waste occurs in many

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guises during intravenous nutrition. The most obvious occurs as a result of the overprescribing of both protein and energy requirements. Though protein and energy needs are much increased during the acute phase of injury, this period is usually short lived and through the normal processes of metabolic adaptation requirements fall rapidly as catabolism is reversed and recovery begins. Thus, although protein losses may approach 0.7 g of nitrogen/kg daily in the acute phase of severe injury, in most surgical patients daily losses of between 0.1 and 0.3 g/kg are more usual.^{15 16} A protein intake of 0.3 g of nitrogen/kg daily is enough to ensure preservation of body protein in patients after major elective surgery or moderate trauma.¹⁶ Protein losses may be massive in the presence of sepsis, but intravenous nutrition is ineffective in these patients in reversing protein derived gluconeogenesis,¹⁷ and consequently the treatment of the sepsis itself remains paramount. The optimal intake of protein in patients with sepsis remains unknown, but from published data there is no justification for matching measured protein losses with prescribed intake.¹⁸

So far as energy requirements are concerned very few surgical patients expend more than 8.4 MJ (2000 kcal)/24 h.¹⁹ This is composed of the resting metabolic expenditure—by far the largest fraction—the active metabolic expenditure, and any increase in energy requirements related to dietary induced thermogenesis.²⁰ The resting metabolic expenditure of patients after uncomplicated general surgery is rarely more than 6.3 MJ (1500 kcal)/24 h and may be much less after severe weight loss.¹⁹ Energy requirements related to active metabolic expenditure are very variable, ranging from zero to 4.2 MJ (1000 kcal)/24 h. One recent study suggests that an additional energy increment equivalent to 50% of the value of the resting metabolic expenditure in preoperative patients and 20% in postoperative patients will be sufficient to meet the energy cost of physical activity in most cases.²⁰ Increases in energy expenditure due to dietary induced thermogenesis may be as much as 25% of the resting metabolic expenditure in the presence of net lipogenesis.²¹ This not infrequently occurs when glucose is the only energy source used. If energy intakes closely approximate requirements, and particularly if glucose and fat are given simultaneously, then dietary induced thermogenesis will be less than 10% of the resting metabolic expenditure.²¹ In critically ill patients receiving intravenous nutrition the value of the resting metabolic expenditure approaches total energy requirements as active metabolic expenditure is very small.²⁰ Even in patients with multiple organ failure due to severe sepsis measurements of energy expenditure rarely exceed 10.5 MJ (2500 kcal)/24 h.^{22 23} The administration of energy in amounts greatly in excess of requirements should be deprecated, not only because it is extremely wasteful but, more important, because there is little evidence that it is associated with any clinical benefit and it may, in fact, be harmful.^{21 24-26}

Waste also occurs during intravenous nutrition as a consequence of prepared solution being discarded unused.^{27 28} Unpublished data from Leeds suggest that it is not uncommon for up to 10% of the contents of a 3 litre bag to be wasted. Plainly this is unacceptable. In the past clinicians have placed great reliance on good nursing care as being the cheapest and most effective means to monitor infusion rates. Regrettably, this is probably no longer the case. The nurse by the bed counting the drip rate should be helped by the use of volumetric infusion pumps or other flow controlling devices, which, though expensive, are much more accurate.^{28 29} Their initial costs would be offset to some extent by the savings incurred in reducing the volumes of discarded fluid.

NUTRIENT SOLUTIONS: WHO NEEDS FAT?

Costs may also be reduced by rationalising the actual nutrient solutions used. This applies in particular to the provision of energy. The choice of energy source lies between glucose alone and glucose in combination with a fat emulsion. Which of these is preferable, however, remains controversial.³⁰⁻³³ Those who prefer glucose alone argue that it is cheap, that blood glucose concentrations are easily monitored, and that its efficacy with regard to protein sparing is irrefutable.³⁴ In contrast, those clinicians who advocate a glucose and fat regimen, while accepting that fat emulsions are at least 15 times more expensive than hypertonic glucose solutions, argue that glucose used alone is associated with a higher incidence of complications.³⁵ There is good evidence to support this view in neonates³⁶ and patients with sepsis or respiratory failure,³⁷ but the evidence is less convincing in other patient groups.³⁵ None the less, it is certainly true that many of the metabolic problems encountered during intravenous nutrition may be attributed to the infusion of large volumes of hypertonic glucose solutions. These include hyperglycaemic and hyperosmolar states, fluid retention, fatty infiltration of the liver, and hypercapnia, which may result in respiratory difficulties in ventilated patients.³⁸⁻⁴⁰ These complications, however, must to some extent reflect the patients' inability to utilise glucose at the rate at which it is being infused.

There is now good evidence to support the concept that there is a physiological maximum to glucose oxidation which if exceeded results in

exogenous glucose being converted to glycogen or stored as fat.^{21 41} Although the absolute value of this physiological maximum probably varies with the clinical state of the patient, recent studies in volunteers, patients with burns, and those with sepsis suggest that it lies between 2.0 and 7.0 mg/kg/min.^{23 41 42} It is most unlikely, however, that glucose infusions greater than 4.0 mg/kg/min can ever be justified in the clinical setting.⁴³ This is equivalent to about 95 kJ (23 kcal)/kg/day or only 6.7 MJ (1610 kcal) a day for a 70 kg subject. On the basis of this evidence it is possible to rationalise the use of glucose or glucose and fat during intravenous nutrition. In the patient with an uncomplicated, non-septic condition in whom it is estimated that energy requirements do not exceed about 95 kJ/kg/day there is no good reason why glucose should not be used alone as the energy source during intravenous nutrition—provided, as always, that the patient is carefully monitored. In the patient with sepsis or in whom a high risk of sepsis exists, or in any patient in whom it is estimated that energy requirements exceed 95 kJ/kg/day, a mixture of glucose and fat should be given. The extra cost of this mixed regimen is justified, not simply because it may reduce morbidity related to intravenous nutrition but because it is wasteful, inefficient, and potentially dangerous to administer glucose in amounts that exceed a patient's ability completely to oxidise it all.

Selecting an energy source on the basis of metabolic efficiency is all very well but it should not detract from the other well known therapeutic advantages of fat emulsions.⁴⁴ These include a low osmolality which permits peripheral infusion, a high energy density which minimises the risks of fluid overload, and a guaranteed provision of essential fatty acids and phosphate in the form of phospholipid, neither of which are readily available from other commonly used preparations for intravenous nutrition. Hence a case can be made for the regular administration of some fat to all patients receiving intravenous nutrition irrespective of their energy expenditure or clinical condition.

WHICH PROTEIN SOURCE?

There is little to choose among the various protein sources now available in terms of their proved efficiency.^{15 45} Essential amino acids should constitute at least 40% of the total given, and all amino acids should be in the laevo form. Non-essential amino acid content should be balanced and solutions containing large amounts of "stuffer" amino acids, such as glycine, should be avoided.⁴⁵ Glycine is a poor energy source and an ineffective precursor of other amino acids. Aminoplex 12 (Geistlich) and Vamin (KabiVitrum) contain proportions of glycine comparable to egg protein (4%), which some authorities suggest is the ideal protein for oral feeding. All other protein solutions contain much more than this which may be wasted, and consequently excluding glycine from the mixture gives a better guide to the cost of usable nitrogen. For instance, the extra gram of nitrogen in Aminoplex 14 is all glycine.⁴⁵

VITAMINS AND TRACE ELEMENTS

Any consideration of the costs of solutions used during intravenous nutrition must also include mention of vitamin and trace element requirements. It is now standard practice in many hospitals to prescribe both water and fat soluble vitamins together with a trace element preparation on a daily basis to all patients receiving intravenous nutrition. This policy necessitates some additional workload on pharmacy staff together with an inevitable increase in costs of intravenous nutrition. It is difficult to justify this practice, particularly with regard to the fat soluble vitamins A, D, E, and K. Deficiencies of these vitamins generally develop more slowly than those of the water soluble vitamins, which are catabolised and excreted more rapidly as well as being stored for much shorter periods.⁴⁶ Furthermore, some authorities now seriously question the validity of administering vitamin D at all during intravenous nutrition in adults, as its primary effect is to promote intestinal calcium absorption.⁴⁷ Vitamin E deficiency states rarely, if ever, occur; vitamin A stores may last for a year or more; and vitamin K may be given by alternative routes.⁴⁸ Hence it is probably unnecessary to provide fat soluble vitamin preparations on a daily basis to all patients.

Deficiency states of the water soluble vitamins C and B develop more frequently and there is little doubt that "complete" intravenous nutrition should include their addition on a more regular basis.⁴⁹ Nevertheless, it is difficult to believe that their omission for short periods, such as weekends, would affect clinical progress adversely. Similarly, although clearly defined deficiency states of certain trace elements—notably zinc, copper, chromium, and magnesium—are well recognised during intravenous nutrition,⁵⁰ their omission for short periods is unlikely to be detrimental in the carefully monitored patient in whom substantial losses are not anticipated. The savings made by excluding all vitamins and trace elements for

just two days a week would amount to only £3000 a year if there were six patients receiving intravenous nutrition at any one time. This amount, however, does not include the potential savings with respect to a reduction in pharmacy workload.

MORBIDITY: WHICH CANNULA?

Further savings in costs may be achieved by keeping morbidity related to intravenous nutrition to a minimum. Fortunately, metabolic complications of intravenous nutrition are uncommon in most well organised departments, and consequently the overall effect of these on the total cost of intravenous nutrition must in reality be small. Possibly of greater importance from the point of view of cost are those complications related to central venous catheterisation. Between 1% and 4% of all catheter insertions are associated with haemothorax, pneumothorax, air embolism, venous thrombosis, or other problems.⁵¹ In some series as many as 10% of all catheters are removed because of suspected sepsis.⁵¹ In an attempt to reduce the incidence of these problems many investigators have turned their attention to the different types of catheter available as well as the effect, if any, of routinely creating a subcutaneous tunnel after catheter insertion.⁵² Most authorities agree that, despite being more expensive, silicone catheters are to be preferred as they are inert and associated with less infection than others.^{53 54} The high degree of flexibility of silicone and its soft, non-wetting surface theoretically minimise the danger of platelet emboli, perforation of vessel walls, and venous thrombosis. The perfect cannula, however, is useless if poor technique is used, and scrupulous attention to detail remains the prerequisite of good catheter care and the best way to keep sepsis to a minimum.⁵²

PERIPHERAL OR CENTRAL VEIN?

Improvements in catheter materials and in the techniques of insertion should not detract from the simplest way of avoiding all these problems of central venous catheterisation—namely, by using a peripheral vein. Peripheral parenteral nutrition can be as effective as intravenous nutrition, providing easier control of infection and simplifying nursing care.⁵⁵⁻⁵⁷ Hence it is probably cheaper than intravenous nutrition given through a central line. Despite these potential advantages many clinicians still prefer the central route, which may reflect the absence of prospective and controlled studies of parenteral nutrition given through either a central or peripheral line such that the efficacy and applicability of peripheral parenteral nutrition in various clinical settings could more precisely be defined. Clearly, it is not applicable in patients without suitable peripheral veins, in those who require unusually high intakes, or when nutritional support is needed for prolonged periods.

PHARMACY COSTS

Finally, great savings in the cost of intravenous nutrition are possible in its preparation. The amount of pharmacy personnel, time, and money required to purchase and prepare intravenous nutrition solutions is tremendous. It is customary in many hospitals, particularly those with a research interest in nutrition, to prescribe separately for each patient without regard to formula standardisation of intravenous nutrition regimens. It is argued that this approach is essential to maintain utmost flexibility in prescribing facilities.⁵⁸

While this is probably necessary in the critically ill patient in whom repeatedly daily assessment may result in a frequent alteration in nutritional requirements, there is, none the less, good evidence that some formula standardisation is possible without detriment to patient care.⁵⁹⁻⁶¹ For example, Selzar *et al* described using a 25% dextrose and 8.5% amino acid solution containing a fixed amount of preadded electrolytes.⁵⁹ They found that their standard solution was appropriate for over 80% of their patients. The study also showed a 37% reduction in workload in the pharmacy when the standard solution was used in preference to the separate addition of each electrolyte required. More recently the Oxford Parenteral Nutrition Team reported its experiences with a standard regimen in which the electrolyte content was not predetermined and found it satisfactory for 70% of patients. The team concluded that the standard regimen facilitated nursing care and was associated with a reduction in morbidity related to intravenous nutrition.⁶¹ Clearly different departments with their particular specialist interests may require different standard solutions, but discussion between clinician and pharmacist should in most cases permit a satisfactory compromise to be reached. It is in this area that the existence of hospital nutrition teams, consisting of pharmacists, dietitians, nursing staff, and medical staff, may be able to make a definite contribution to reducing the costs of intravenous nutrition. Adopting standard intravenous nutrition

regimens is cost effective, not only because they reduce pharmacy workload but also because they permit the bulk purchase of nutrients and minimise the waste that occurs when individually prepared solutions are discarded unused.

Conclusion

In conclusion, the costs of intravenous nutrition may be reduced, without compromising efficacy, by considering the following questions: Is intravenous nutrition really necessary? What are the patient's requirements and what is the safest way to administer them? and, finally, Have these been discussed with the pharmacist?

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Personal Paper

Stammering

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I have never known what it is to speak freely without the knowledge that lurking ahead somewhere is an unexpected and insurmountable log jam of words. One of my earliest recollections is of going to a sweet shop to spend my "Saturday penny" and coming away in rage and frustration with something I did not want because the words "liquorice laces" would not come out.

It did not seem to worry me, or anyone else, until I got to the age of about 9. Then some would ask, "What will you do when you grow up?" and there was the inevitable fun making at school, which I hotly resented. The recommended treatment was elocution, which I liked because it entailed reading and learning poetry. There were breathing exercises and relaxation, which all helped the flow of language once the flow was established. But it was the apparent trivialities of conversation that produced such enormous and frightening problems. Saying hello or goodbye, or introducing myself or someone else, was often a nightmare that I would do almost anything to avoid. Silly little things like being asked by an adult the way, or what my name was, I would go to extremes to evade. Friends were never short of advice, such as to talk with a mouthful of pebbles like Demosthenes, the patron saint of stammerers—it can be done but is difficult and quite hazardous. If anyone is to occupy the prime place as the hero and example for all stammerers, it is surely King George VI. They say that stammerers never stammer when they sing, which is largely but not entirely true, but to suggest that you should go through life singing all conversations may be good comic opera but is not a practical proposition. Then, too, there were the psychotherapists, all delightful people with whom I spent many an hour but with no apparent improvement.

This blight on conversation meant that at school I was a loner, had

few friends, was passed over in reading aloud in class, never took part in school plays, and never became a prefect. Talking to myself, aloud, was marvellous, and I would go for long country walks reciting poetry. As I got older the social handicap became more apparent. Standing in a queue shopping or at a ticket office with people waiting behind me was most trying, and I would often resort to a pencil and paper to save embarrassment. Many well meaning people would try to help by guessing what I was trying to say, and this could result in a quite deplorable situation—if they guessed wrong then I had the additional problem of telling them and starting again. If they guessed right I wanted to thank them, and this was one more problem to overcome.

Then there loomed the awful problem of "What are you going to do when you leave school?" Adverts in papers like "Try my method; I can cure you as I cured myself" promised much and disappointed greatly. Some I am sure depend on the natural spontaneous remission in many cases. This all built up to a crisis that produced the state of mind in which I seemed to say, "Never mind what they say, I want to be a doctor." An understanding headmaster, a sympathetic medical school dean, success in gaining an entrance scholarship including success in a viva voce exam, and I was in. From then on it was by no means easy, and viva voce exams in the finals appeared like the Rocky Mountains to the builders of the Canadian Pacific Railway, but it was done.

Once qualified I encountered an entirely new situation. As long as I was with a patient there were few problems. Speaking came naturally because I was the doctor and could speak in my own time, and the patient had to listen. Conversation is not only speaking, it is also holding the attention of the other. If only people would listen and wait it would be so helpful. The concentration sometimes required to navigate a treacherous sentence is such that even if the heavens should fall I would still be concerned with the letter B coming along like a hurdle in a race. Ivan the Terrible, it is said, had a walking stick with a sharp spike with which he transfixed the foot of anyone he wanted to talk to. How I envied him on occasions.

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