Hospital Topics

A rational approach to parenteral nutrition

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Parenteral nutrition has been slowly gaining ground in Great Britain. As with anything new (or in this case thought to be new, because enthusiasts have been active for a quarter of a century) the initial detailed experience of the few has been translated into general prescriptions for use by the many. In particular, the last few years have seen the development of simple regimens, sometimes even single solutions, which aim to satisfy the needs of a wide variety of clinical circumstances. Though we do not want to decry the easier availability of parenteral nitrogen and calories which single solution regimens—package formulae as it were—have produced, we are alarmed by three features of current parenteral nutrition. One is the fallacy that a uniform diet is always appropriate, particularly in the seriously ill, who, as well as changing energy requirements, also have a widely fluctuating need for water and bulk electrolytes (sodium, potassium, and phosphate). Secondly, the basic requirements for minerals and trace elements such as calcium, magnesium, zinc, and manganese are so often neglected. Thirdly, we are alarmed that the very ease with which parenteral nutrition of a kind can now be presented may, on the one hand, deprive some patients of the expert care and decision-making required to solve their underlying problem and, on the other hand, lull the prescriber into thinking that as with the specification of a diet all that is required is to annotate the diet sheet—administration and control can safely be left to others and complications can be discounted.

Our experience suggests that a more flexible and concerned approach is needed by anyone who takes on the responsibility of prescribing parenteral nutrition. In an endeavour to provide the groundwork for rational and reasonably well-controlled feeding for individuals (particularly those with surgical illness), we have codified our own practice with special reference to (a) the basic indications for feeding as they can be seen in 1976; (b) the regimens and composition of solutions to meet the needs of flexibility and simplicity; (c) the prevention of hazards; and (d) the development of team skills. All four of these areas should be emphasised because the casual use of parenteral nutrition may bring it into disrepute and, furthermore, much money may be wasted. Our relatively simple approach may offend the parenteral nutrition technocrat who has come to surround his specialty with a disproportionate amount of mystique. On the other hand, it may appear more complicated than necessary, though we believe this is not the case. Our advice is based on several years' practical experience with acutely ill surgical patients—a group which presents the most difficult problems of

the control of water and electrolyte balance and the containment or prevention of sepsis.

Indications

A list of indications cannot be exhaustive, but we give below the major established indications. It is of paramount importance that parenteral feeding should be considered early in the patient's clinical course. All too often the decision to "feed" is delayed until frank malnutrition has developed. There is then a long, and sometimes unsuccessful, haul back towards normality. The decision to withhold parenteral nutrition should be seen as a positive action which will starve the patient and must in itself be justified.¹

Preoperative supplemental feeding should be carried out in any patient who has lost more than 5 kg weight before admission, particularly those with carcinoma of the oesophagus and stomach who are facing major surgery. There is evidence to suggest that these patients have impaired wound healing and immunological defence mechanisms and that preoperative feeding can at least partially reverse the abnormalities.² Postoperative morbidity and mortality is probably also reduced.³ Direct controlled information to justify these statements is not available nor is it ever likely to be, but starvation is an abnormal state and should be avoided in the context of major illness or surgery. Some patients may be managed by effective oral feeding with mixed food or an elemental diet, or both; but some, particularly those with gastrointestinal obstruction, need parenteral nutrition.

Postoperative feeding should be carried out in any patient who is not progressing favourably and who cannot take oral nutrition 72 hours after surgery or trauma. If there is associated sepsis such patients may be losing up to 0.5 kg of their lean body mass a day, and impaired resistance to infection and poor wound healing are inevitable consequences of protein depletion. It is always easier to maintain nutrition than to replace lean body mass that has been lost. Such maintenance should be the objective of all surgical care.⁴

Intestinal fistulas—Since the advent of complete intravenous nutrition the morbidity and mortality of gastrointestinal fistulas has fallen dramatically.⁵ In a recent report of 78 fistulas in 62 patients treated by total parenteral nutrition 70% of the fistulas closed spontaneously after a mean of 35 days; operative intervention was required in only 22%, and the mortality rate was 8%.⁶ This should now be the norm of management. Again, oral nutrition (particularly with an elemental diet that provides a low residue and is predominantly absorbed proximal to the fistula) may be helpful, but when sepsis and previous starvation have resulted in loss of body mass the initial treatment should nearly always be by the parenteral route.

Postoperative renal failure—Carefully planned parenteral nutrition provides a useful means by which a patient's intake of food may be precisely controlled. Glucose and insulin may also be selectively used to limit the rate of rise of both potassium and urea.⁷

Inflammatory bowel disease—It is not improbable that the reduction in gastrointestinal secretions in patients treated with total parenteral nutrition⁸ plays some part in decreasing the risk and severity of relapses of small bowel inflammatory disease.⁹ The role of parenteral nutrition in patients with ulcerative colitis is less certain and is probably no more than supportive.

Adjunct to cancer chemotherapy—Malnutrition probably plays a major part in the death of most patients with malignant disease. It may seem questionable to use parenteral nutrition under such circumstances. Nevertheless, if criteria are strictly defined it may be possible to prolong useful and acceptable existence in more than a

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third of patients who would otherwise be denied treatment because of complications from malnutrition and inanition.¹⁰ Both enteral and parenteral nutrition can contribute to the quality, if not the quantity, of survival.

Burns—Severely burnt patients are nearly always hypermetabolic, partly because of the extent of injury, partly because of the cooling effect of large evaporative water losses. Even if the patient can eat, oral nutrition alone cannot supply enough calories or contain the negative nitrogen balance of a large catabolic response.

Massive small bowel resection—The minimum length of small bowel capable of supporting life is probably about 30–45 cm. When less than this is available—for example, after resection for trauma or infarct—then long-term or even lifelong nutritional support is required. Such patients are best treated and supervised from specialised centres.^{11–13}

Regimens

It is useful to consider two levels of parenteral nutrition to deal with the common circumstances that we have just listed. For relatively short-term supplementary feeding—for example, in the post-operative but non-complicated patient—a simple nutritional regimen for a few days (maximum a week) may suffice. All other patients need total parenteral nutrition, which is more complicated and demanding.

SIMPLE NUTRIENT REGIMEN

A useful parenteral nutrition regimen that can be administered by peripheral vein is shown in table I. It is appropriate for relatively short-term nutrition. Although the total energy intake is only 6.69 MJ (1600 kcal) this is a considerable improvement on the ubiquitous “3 litres of dextrose-saline,” which gives a mere 2.40 MJ (575 kcal) in the absence of nitrogen and trace elements.

TABLE I—Regimen for parenteral nutrition via peripheral vein

	Total contents
2 × 500 ml Vamin glucose*	Energy 6.7 Mj (1600 kcal)
1 × 500 ml dextrose 10% } Compatible	Water 2780 ml
1 × 500 ml dextrose 10% } additives	Carbohydrate 200 g
as indicated	
1 × 500 ml Intralipid 10%*	Nitrogen 9.4 g (≈ 70 g protein)
1 × 500 ml Hartmann's solution	Fat 50 g
Additives per 24 hours to be mixed with dextrose or Hartmann's solution only:	Sodium 115 mmol
Parentrovite 1 and 2 (or similar multivitamin)	Potassium 25 mmol
Addam solution, 1 phial*	(+ 20–40 mmol added)
Potassium 20–40 mmol to required daily total	Calcium 7.5 mmol
Vitamin K if required	Magnesium 3 mmol
Folic acid 15 mg/week intramuscular	Phosphate 15 mmol
	Other trace elements in normal daily amounts: zinc, iron, manganese, and copper (Addam solution*)

* KabiVitrum Ltd.

The calorie intake may be increased by substituting 20% for 10% fat emulsion, thereby adding a further 1.88 MJ (450 kcal). It is wise to start with the weaker solution, however, and gradually work up to the full regimen, especially with severely malnourished patients. The same argument applies to carbohydrates; thus 5% dextrose should be used for the first 24 hours. More important is that in patients who are particularly susceptible to complications from concentrated fat emulsion or carbohydrate solutions a simple regimen is usually not indicated.

If the patient's sodium loss is low—for example, after operation—then 500 ml of Hartmann's solution can be replaced with isotonic dextrose-saline, thereby reducing the sodium input to 64 mmol(mEq)/24 hours. Metabolic disturbance or electrolyte imbalance is unlikely to result from such a regimen, but this is no excuse for the relaxation of vigilance in the metabolic management of the patient, which should approximate as closely as possible to that for full intravenous nutrition.

There are two advantages of the use of peripheral veins for infusing such a regimen over relatively short periods. Firstly, the incidence of septicaemia is lower, because if a cannula does become contaminated then peripheral thrombophlebitis will probably develop, and although this is painful for the patient it is safer because the infusion will be discontinued. Secondly, parenteral nutrition may be administered without reliance on the expertise and resources required for central venous catheterisation. Although many of the solutions used are

hypertonic the cannula should not need to be changed more often than every two to three days. As we have already emphasised, however, this may encourage the casual use of parenteral treatment and the neglect of all the adjuncts to it which may be necessary for survival of the malnourished patient.

COMPREHENSIVE PLAN FOR COMPLETE PARENTERAL NUTRITION

Patients who require parenteral nutrition for more than one week and those with complex metabolic problems are more appropriately treated with a central venous catheter. In our experience a subclavian catheter inserted by the infraclavicular route provides greatest comfort and ease of nursing; it also gives a reliable “life-line” for fluids in any eventuality and may be left in place for up to six weeks. Nevertheless, we still await the perfect catheter for such a technique,¹⁴ and septic complications are still all too common.¹⁵ Infraclavicular puncture has been well described¹⁶ and will not be considered here.

Given that a central venous catheter confers freedom to administer hypertonic solutions, the practical therapeutic problem is to combine the optimum in flexibility of administration of water, electrolytes, energy, nitrogen, and trace elements that have a known role in man with the use of a minimum of solutions that carry the maximum safety. The resolution of this complex problem can come only from listing the desiderata and constraints and attempting to meet them simultaneously (table II). As with any multivariable problem some of the desiderata are mutually contradictory and a compromise has to be reached. It is true that by setting up an expensive hospital-based mixing service greater flexibility would be achieved,⁹ but we do not think that this would be justified in most hospitals.

TABLE II—Various desiderata of treatment and ways of achieving them

Desiderata	Method of achievement
Ability to administer high and low sodium intakes	Low sodium content amino-acid solutions
Reduce risk of hyperosmolar states, avoid rebound hypoglycaemia	Routine dextrose solutions no stronger than 20%
Supplemental calories above basal	Use of fat emulsion
Routine administration of phosphate and trace elements ^{11, 21, 22}	Use of added 50% dextrose
Variation in potassium content	“Packaged” elements in routine dextrose solutions
Minimum additives	Added rather than incorporated potassium
Avoid lactic acidosis ²³	Incorporate trace elements as above
Use best utilised amino-acid solutions	Use glucose solutions
Avoid vitamin and acute folate deficiencies ²⁴	Conform to outcome of previous work ²⁵
	Avoid ethanol
	Daily multivitamins
	Weekly folic acid

The six solutions that have resulted from pooling the information and decisions in table II can then be combined in various ways to provide six commonly used regimens (table III) which we have found satisfactory for nearly all acute illnesses. They should not be followed exclusively or slavishly, but they do provide a useful base. The form of table III permits the easy selection of the appropriate prescription for 24 hours and is a ready reference for nursing staff.

General management and prevention of hazards

Once the decision has been made to start parenteral nutrition then a considerable responsibility falls on the medical team for the fluid, electrolyte, and metabolic surveillance of the patient. Table IV contains a list of investigations that ideally should be undertaken in addition to any others required for the patient's primary illness. This list is appropriate for the patient who has undergone acute surgery and, as such, could be abbreviated when a patient is in a more stable metabolic state. The most important aspect of this surveillance is monitoring the daily urinary urea and electrolyte levels and fluid balance and testing urine for sugar, because only with such information can the next day's regimen be prescribed with confidence and safety for the patient.

To strike a balance for water is common surgical practice. Less usual is an attempt to do this for electrolytes or for nitrogen flux in the body. Nevertheless, in patients fed intravenously, particularly those with additional fluid and electrolyte losses such as often occur in surgical practice, it is essential. Parenteral feeding solutions contain variable quantities of sodium and potassium and it is all too easy to

TABLE III—Six basic regimens for acutely ill patients

Bottles/24 h						Contents/500-ml bottle	MJ	Water (ml)	Carbohy- drate (g)	Nitro- gen (g)	Fat (g)	Elements (mmol)							
												Na	K	Cl	Mg	Ca	Zn	Mn	P ₀₄
2	1	1	2	1	2	Vamin glucose*	1.36	460	50	4.7		25	10	28	0.8	1.3			
	1	1	1	1	1	Aminosol 10%*	0.69	460		6.4		80	0.2	60					
	1	1	1	1	1	Electrolyte solution A with 20% w/v dextrose†	1.67	500	100					27	14	13	0.04	0.02	
	1	1	1	1	1	Electrolyte solution B with 20% w/v dextrose†	1.67	500	100				30					30	
	1	1	1	1	1	Dextrose 50%	4.18	500	250										
	1	1	1	1	1	Intralipid 20%*	4.18	400			100								
						Low sodium	10.24	2320	300	9.4	100	50	50	83	15.5	16	0.04	0.02	30
						Standard	9.57	2320	250	11.1	100	105	40	115	14.8	14	0.04	0.02	30
						High sodium	8.90	2320	200	12.8	100	160	30	147	14	13	0.04	0.02	30
						Fat-free	9.57	2420	500	11.1		105	40	115	14.8	14	0.04	0.02	30
						Increased calories	13.75	2820	500	11.1	100	105	40	115	14.8	14	0.04	0.02	30
						Increased calories, low Na	14.42	2820	550	9.4	100	50	50	83	15.5	16	0.04	0.02	30

*Kabivitrul Ltd. †Travenol Ltd.

Daily additives (not to fat emulsion): K⁺ up to patient requirement; Parentrovite ampoules 1 and 2. Weekly additives: folic acid 15 mg intramuscularly; vitamin K 10 mg unless contraindicated.

Conversion: SI to traditional units—Energy: 1 MJ ≈ 239 kcal.

create imbalance, especially if there are renal constraints on sodium excretion or a particular preparation is used exclusively. One of the failures of treatment is to nourish the patient effectively but make him oedematous. Serum concentrations of sodium are *not* a guide. A rough balance, which is well within the capabilities of the general surgical team, is far more revealing.

The need to measure nitrogen excretion is less pressing, but the daily excretion of urea (which represents a fairly constant 75–80% of total urinary nitrogen) is a good guide to the fine adjustment of nitrogen intake. There is an almost innate tendency to overprescribe nitrogen in parenteral and oral nutrition for sick patients. Measurement may help to avoid this and more properly relate nitrogen needs to prescription, so avoiding the risk of raising the blood urea concentration.

TABLE IV—Routine investigations: substances to be measured and tests to be performed at various intervals

Daily	Twice weekly	Every two weeks
Haemoglobin, full blood count	Liver function tests	Zinc
Urea and electrolytes	Calcium and phosphorus	Magnesium
Urinary urea and electrolytes	Sugar	Iron and total iron binding capacity
Urine testing for glucose	Osmolality	Folate
	Blood culture	B ₁₂
	Urinary calcium and phosphorus	
	Body weight	

The two major problems that can steal up on the clinician unawares, but with a rapidity that requires urgent action, are hyperglycaemia and hyponatraemia. Patients on parenteral nutrition in the acute aftermath of major surgery or injury have changes in carbohydrate metabolism and in the intra-to-extracellular sodium fluxes which last for at least 10 days and probably as long as any complications persist. Large carbohydrate loads are less well tolerated than usual and may cause non-ketotic hyperglycaemia¹⁷ with hyperosmolality, the effects of which are mainly on the brain and in the induction of a solute diuresis. The last causes secondary dehydration. It should be emphasised that the rise in extracellular osmolality of this type is devoid of specific signs. Hyponatraemia is an accompaniment not a result of parenteral treatment, but its high incidence in the group mentioned demands careful observation of serum sodium concentration. There may be many causes of failure to thrive in a patient on parenteral nutrition, but in our experience a low sodium state is one of the commonest causes. A persistent glycosuria of more than 1% and a fall in serum sodium concentration either steadily by at least 5 mmol/day or to a value of 125 mmol or less all require urgent therapeutic action.

If the urine persistently contains more than 1% sugar during carbohydrate infusion then either the carbohydrate load should be reduced, or, because it is usually essential to maintain a high calorie intake, 10–20 units of soluble insulin should be added to each 500 ml 20% dextrose. More insulin may be needed than this because there are considerable losses in the flask by adherence to glass. Patients who

become seriously ill after major surgery or those with sepsis, particularly those with hyponatraemia and heart failure,¹⁸ are more appropriately treated with a formal glucose, potassium, and insulin regimen.⁷ The reason for this is that the bolus technique of administering dextrose and insulin in the first 10–20 minutes of each infusion hour, which is a usual feature of this form of management, permits easier control of blood and urine sugar levels. The remaining 40–50 minutes can be used either for additional parenteral nutrition or water and electrolyte replacement.

We recommend that it be the daily duty of *one* member of the medical team to consider the metabolic and electrolyte status of a patient and then to prescribe for no more than 24 hours. A regular format should be cultivated so that fat emulsion is always started mid-morning—that is, after daily blood samples have been withdrawn—and ended at a convenient time for day staff to change the infusion set. These measures define more clearly the role of the nursing staff. They also prevent ad hoc prescription, which generally leads to confusion. Balance sheets that account for fluids, sodium, potassium, nitrogen, and calories are highly desirable even if they must be filled in only on an approximate basis either because laboratory facilities are not fully available or because there is a delay in reporting.

“Locking off” the cannula—We do not eat continuously. Yet when an intravenous infusion is established we seem to feel that it must be kept going round the clock. In complicated parenteral therapy this may be disadvantageous in that when nursing staff are few and fairly inexperienced trouble is more likely at night. It is simple to stop parenteral nutrition at this time. A locking on-off tap is always connected to the catheter in our patients; 0.5 ml of heparin in saline 1000 U/ml is injected and the tap switched off and covered by a sterile dressing. A new infusion apparatus is connected the next morning.

CATHETER CARE

Whether the patient is being fed through a peripheral cannula or a central venous catheter, aseptic technique on insertion and in subsequent nursing care is likely to determine success or failure. Sepsis in malnourished patients may be fatal, and most nutrient solutions make excellent culture media. A strict aseptic technique must therefore be used at all times and particularly when the bottles are being changed.

Organisms can reach the tip of a catheter by three routes. Blood-borne sepsis can be minimised only by appropriate treatment of other septic foci, but access to the catheter from the inside of the drip bottle or tubing and from around the catheter are entirely preventable by good nursing and medical care. The catheter must not be allowed to move to and fro in and out of the puncture site and its environment must be maintained dry and sterile. The most satisfactory way to achieve this is by the use of dry povidone-iodine aerosol (antibiotic ointment may encourage the growth of fungi).

The parenteral nutrition catheter should be regarded as sacrosanct; it should not be used for blood sampling, blood transfusion, intermittent intravenous drug therapy, or central venous pressure monitoring. If such techniques or facilities are vital then a further central catheter or peripheral cannula should be inserted.

If a patient with a central venous catheter develops an unexplained fever then a first axiom is that the catheter should be removed. In surgical patients, however, where other causes of sepsis abound, there is only a 50% probability that the catheter has caused the fever.¹⁹ A systematic approach to each case is needed and can be achieved by using a simple logic chart,¹⁵ which reduces significantly the unnecessary removal of a vital lifeline.

Team approach

Undoubtedly the ultimate success of parenteral nutrition depends not only on medical staff but also on nursing staff and pharmacists. Liaison and co-ordination between these groups are vital. There is also the constant problem of staff turnover with new members unfamiliar with established practice.

We find that the most successful way of managing this type of nutrition is by having a clearly defined team organised by a single member of the medical staff. The objectives of the team are co-ordination and education with a view to maintaining standards. Regular meetings of the team ensure that even the most trivial problems are adequately discussed.²⁰ Furthermore, education in new techniques and modification of existing practices are more swiftly and easily achieved.

Conclusions

To feed a patient by a vein is now technically feasible and often clinically advisable. To do so effectively requires us to bring to prescription, methods, and control standards that are as high as in any other therapeutic field. We have attempted to delineate some of these standards and would emphasise again the need for acquiring skills and placing the technique and patients who require it into the hands of only those who are both interested in the problem and determined to succeed.

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Letter from . . . Victoria

Drivers and health

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Election time again

In Australia there is almost always an election in the offing. Last year saw a State election in South Australia and a Federal election. This year the Victorian and New South Wales governments have to face the people. Only in Tasmania is the life of the Parliament more than three years and as the elections to the Federal Senate and House of Representatives are out of step the voters have to trudge to the polls at least once a year. And anyone who fails to vote is fined, as voting is compulsory.

Before every State election the opposition makes much of the government's failure to meet its election promises, while the government suddenly becomes interested in announcing policy decisions which it has been avoiding for years. An example in Victoria this year is legislation for random breath-testing of

drivers. Another indication that it is an election year was the amazing indictment of the Health Department and its Minister on television by Mr Hamer, the Premier of Victoria.

The road toll

Australia is close to the top of the international table for road deaths adjusted for population. Over the years the Victorian Government has been the leader in road safety legislation. It was the first State in Australia to introduce the compulsory wearing of seat belts if they were fitted to the car and the compulsory fitting of seat belts in all cars sold (at first for the front seats and then for all passengers), and it was the State with the lowest permitted blood alcohol level (10.9 mmol/l (50 mg/100 ml)) with the other States choosing 17.4 mmol/l (80 mg/100 ml). About two years ago legislation was passed which compelled hospital doctors to take a blood sample for measuring blood alcohol concentrations when treating anyone who had been in a car accident. The hospitals co-operated but the police often failed to collect the samples, seldom had them analysed, and only occasionally used them as evidence in court cases. Pressure from

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