Nutritional support in renal failure

Module 15.4

Nutrition support in peritoneal dialysis patients

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Learning Objectives

- To know the causes of undernutrition in PD;
- To learn how to evaluate nutritional status in PD patients;
- To learn the nutritional requirements in PD patients
- To know the different techniques of nutritional support in PD patients;
- To learn the best approach to nutritional support in malnourished PD patients.

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Key Messages

- Protein energy wasting is found in approximately 30-40% of patients on peritoneal dialysis (PD);
- PD patients with protein energy wasting have a compromised prognosis;
- The main causes of undernutrition in PD are similar to those in HD treatments. These include insufficient food intake, abnormal nutrient metabolism, inflammation, and hormone abnormalities;
Specific factors due to PD treatment additionally affect the nutritional status of PD patients. These are a lower eating drive, important protein losses through the peritoneal effluents and the extra glucose load from peritoneal dialysis solutions;

- Compared to HD patients, body composition in PD patient is characterized by fluid overload and gain of fat mass. Loss of lean body does not appear to differ from that in HD patients;
- Protein energy wasting can be detected by a decrease in body mass index, a body weight loss > 10% within 6 months, serum albumin < 35 g/l and serum prealbumin < 300 mg/l;
- Nutritional support, preferably in the form of amino acid-based intra-peritoneal parenteral nutrition (AA-IPPN) and possibly oral nutritional supplements (ONS), is able to improve nutritional status;
- In patients presenting with mild malnutrition as defined by insufficient spontaneous intake, dietary counselling, and, if necessary, AA-IPPN are worth trying initially. There is little evidence that the use of ONS is efficient in this population. If ONS are used, sustained compliance has to be optimal in order to improve nutritional status;
- In patients exhibiting severe malnutrition, with spontaneous intakes more than 20 kcal/day: dietary counselling and AA-IPPN should be prescribed; enteral nutrition may be necessary if the above measures do not improve the nutritional status;
- In patients exhibiting severe malnutrition, with spontaneous intakes less than 20 kcal/day, or in stress conditions, daily nutritional support is necessary. Enteral is preferred to parenteral nutrition, provided that the gut is functional.
1. Introduction

Peritoneal dialysis (PD) is a well established treatment modality in patients with chronic kidney disease (CKD) stage 5. Protein-energy wasting has a high incidence and prevalence among patients undergoing PD (1). In a cross-sectional study, the prevalence of undernutrition in PD patients was 42%, versus 32% in patients treated by haemodialysis (HD) (2). In particular, serum total protein and albumin tended to be lower, midarm muscle circumference were similar and relative body weight, skinfold thickness, and the estimated percent body fat tended to be greater in PD patients (2). Differences in nutritional status between PD and HD patients may be explained by specific factors associated with PD treatment. These include fluid overload, important protein losses and the absorption of glucose from PD solutions through the peritoneal membrane. As a result, PD patients may develop a positive energy, together with a negative protein balance. An increase in body fat mass and weight over time on PD are frequently observed. However, muscle wasting does not appear to be more pronounced in PD than in HD patients (3).

Several nutritional parameters in PD patients are correlated with increased morbidity and mortality, which is consistent with observations in patients treated by HD. Low serum albumin (4), decreased urea nitrogen appearance (5), decreased lean body mass (6), low serum creatinine (7) and low nutrition scores as measured by the subjective global assessment (SGA) (6) are all associated with high morbidity and mortality in this setting. Unfortunately, whether any improvement in the above parameters, as a result of nutritional support, has a positive impact on the outcome of PD patients is unknown. To address this question would need large multi-centre trials, which are unlikely to be performed in the near future in this population. Until such specific data is available, data obtained in other conditions and clinical experience suggest that nutritional status in PD patients should be assessed regularly and nutritional support begun if undernutrition is detected. The purpose of this module is to describe and discuss the main issues related to nutrition in PD patients.

2. Specific factors inducing protein energy wasting in PD

Insufficient food intake, abnormal nutrient metabolism, inflammation, and hormone abnormalities are the main causes of undernutrition in patients undergoing either HD or PD (1). However, factors specific to PD also affect nutritional status in PD patients.

2.1 Eating behaviour

Clinical experience suggests that PD patients are more likely to report early satiety or feelings of fullness. A study which investigated eating behaviour in dialysis patients indicates that those undergoing PD have a lower food intake and a poorer appetite compared to HD patients (8). Impaired gastric emptying may explain this abnormality since the instillation of dialysate into the peritoneal cavity may contribute to abnormal gastric electrical activity (9) as well as to prolongation of gastric emptying time (10). At least two other explanations have been put forward to explain the suppression of appetite in PD patients: A) the abdominal distension produced either by intraperitoneal instillation of large volumes of dialysate or by the large ultrafiltration induced by hyperosmolar PD solutions, as shown in rabbits (11) and B) the nutrient-specific role of PD fluids demonstrated in a rat model of PD: the instillation of glucose-based dialysate resulted in a dose-dependent suppression of carbohydrate intake only, whereas the instillation of an amino acid-based dialysate produced a dose-dependent suppression of both carbohydrate and protein intake (12). This latter observation may be relevant because a variety of PD fluids including glucose-based, aminoacid-based and glucose polymer-based solutions are available commercially. However, whether these experimental findings in animals are reproducible in PD patients is unknown.

2.2 Gastro-intestinal symptoms

Gastro-intestinal symptoms such as pain, constipation, diarrhoea, and stool urgency are more frequent in dialysis patients than in the general population of patients (13). A cross-sectional comparative study has also shown that patients on PD have a higher prevalence of gastro-intestinal symptoms than HD patients (14). However, this difference was not found in another study (13).

2.3 Protein losses

Therapy-associated losses of proteins during PD are much higher than in HD, as are losses of protein-bound substances, such as trace elements. They approximate to 10 g/day, whereas amino acid
losses amount to 3-4 g/day, including 30% of essential amino acids (15). Protein losses may increase dramatically to between 15 and 100 g/day in severe peritonitis (16). Protein losses from PD effluents mainly include albumin, and immunoglobulins, whereas transferrin and β2-microglobulin are lost in small amounts. In patients undergoing automated PD (APD), comparable or slightly higher 24-hour dialysate protein losses are observed compared to those reported in continuous ambulatory peritoneal dialysis (CAPD) patients (17).

2.4 Glucose absorption through the peritoneal membrane
Because peritoneal solutions with a high glucose content are standard, PD treatment is associated with a glucose uptake of 100 to 200 g/day (15), which is further increased during peritonitis. Glucose absorption can be estimated in terms of calories absorbed. However, this amount of energy can vary considerably from individual to individual, depending on peritoneal membrane transport characteristics and dwell times of PD solutions. The average peritoneal glucose energy intake is 8 kcal/kg/day, varying from 4 to 29 kg/kg/day or 300-450 kcal/day (18,19). The glucose absorbed accounts for 12 to 34% (mean 20%) of total energy intake (16). Consequently, PD patients, although having a low spontaneous energy intake of about 23-24 kcal/kg/day (20), receive a relatively high total energy intake of 29 to 33 kcal/kg/day (21). This compares favourably with the total energy intake observed in HD patients (22-29 kcal/kg/day) (22).

The high glucose load is responsible for hyperinsulinaemia, insulin resistance, induction or aggravation of diabetes, hypertriglyceridaemia (60% of patients) (15) and increased LDL and VLDL cholesterol.

Many PD patients are reported to have a better renal residual function than HD patients. As a consequence, electrolyte derangements in these patients are usually less pronounced than in HD patients. However, a recent randomized study reported a similar decline in residual renal function in PD as in HD patients using biocompatible high flux membranes and ultrapure water in the dialysate (23). Thus, the historically claimed advantage of PD over HD in preserving renal residual function may be obliterated if patients are matched for dialysis vintage and if the HD technique used follows the above standards.

3. Body composition analysis in PD patients
Clinical observations suggest that overhydration is a usual feature in PD patients. In addition, the enhanced loss of proteins in PD induces protein wasting. However, with the extra glucose load, body weight may increase over time, due to increased body fat mass. The body weight increases between 1 and 5 kg during the first year of PD treatment, and tends to stabilize (or slightly increases) thereafter (24-26).

Precise body composition studies in PD patients are rare, but they appear to corroborate clinical findings. Total body water as assessed by deuterium oxide dilution is in fact no higher than in controls (27). However, the ratio extracellular/intracellular water, using bromide dilution to measure the extracellular water compartment, is increased (27). Body cell mass, assessed by total body potassium count, decreases over time during PD, whereas body fat may increase in parallel (26). Hence, body composition in PD patients is characterised by a relative fluid overload, high fat mass, low fat-free mass and low serum albumin and prealbumin.

4. Nutritional assessment in PD patients
Serum albumin, prealbumin, creatinine and creatinine index, dietary protein intake (DPI) obtained by interviews and diaries, protein equivalent of nitrogen appearance (nPNA), subjective global assessment (SGA), anthropometry and dual-energy X-ray photon absorptiometry (DEXA) are all measures used to assess nutritional status in dialysis patients including those on PD treatment.

4.1 Serum albumin and prealbumin
Serum albumin is not a clinically useful measure for protein/energy nutritional status in PD patients, when used alone. Hypoalbuminaemia in dialysis patient does not necessarily indicate protein energy wasting. It also reflects several non-nutritional factors which are frequently present in PD patients, including infection, inflammation, hydration status, peritoneal and urinary albumin losses, and acidaemia (28, 29). Similar arguments apply for prealbumin, which is a negative acute phase
reactant like albumin, and thus may not correlate with changes in other nutritional parameters. In addition, the prealbumin level is related to residual renal function (30).

4.2 Subjective global assessment
SGA is a useful and reproducible instrument for assessing the nutritional status of PD patients (4,6,31). It is inexpensive, can be performed rapidly, and reflects a global score of protein-energy nutritional status. There are several different versions of SGA that have been applied in different studies. However, no systematic studies comparing different versions of SGA (or the different components included in the SGA) have been reported. Therefore, no particular version of SGA is superior to the other.

4.3 Dietary protein intake and protein equivalent of nitrogen appearance
nPNA, which is an estimate of DPI, is well validated and simple to use in the clinical setting (32). However, there are several important limitations of nPNA as an estimate of DPI. First, nPNA approximates DPI only when the patient is in nitrogen equilibrium or steady state. It will change in anabolic or catabolic situations and in circumstances of marked variation in protein intake (e.g. in a diabetic patient with gastroparesis). Second, nPNA may overestimate DPI when the protein intake is <1 g/kg/day, possibly due to protein catabolism. Finally, normalizing PNA to body weight can be misleading in obese, malnourished and oedematous patients (33). It is thus recommended that, for individuals who are <90% or >115% of standardized body weight, the oedema-free adjusted body weight is used to normalize PNA.

4.4 Anthropometric measurements
The anthropometric parameters that are generally assessed include body weight, height, skin-fold thickness, midarm muscle circumference, percentage of the body mass, the percentage of usual body weight, the percentage of standard body weight and the body mass index (BMI). These various measures provide different information concerning body composition and it is advantageous to measure more than one of them. The use of anthropometrics is easy and cheap to apply. However, this is an indirect and rather insensitive method with several errors, including sensitivity to hydration status and operator-dependency. These measures can be recommended for routine assessment of nutritional status, bearing these limitations in mind (34).

4.5 Hand grip strength
There has recently been an increased focus on functional tests. Hand-grip strength is a cheap and simple method that agrees reasonably well with other measures of nutritional status (35). It has, furthermore, been demonstrated to predict outcome in PD patients (36), and may thus be recommended for routine follow-up of PD patients.

4.6 Dual-energy X-ray absorptiometry
DEXA provides accurate data on body composition which are superior to anthropometry, creatinine kinetics and bioelectrical impedance (37). Although the estimation of fat mass using DEXA is unaffected by abnormalities in hydration status that are common in PD patients, the estimation of lean body mass is affected by the hydration status.

4.7 Recommendations for nutrition status monitoring
It is recommended that nutritional status should be assessed every 6 months using a panel of measures. Regular follow-up is needed in order to identify significant changes or trends in nutritional parameters, which may trigger nutritional interventions (34).

Table 1 gives a summary of nutritional parameters in PD patients and the proposed intervals of measurements for each of them.
Table 1 proposed nutritional parameter monitoring in PD patients

<table>
<thead>
<tr>
<th>Nutritional parameters</th>
<th>Intervals (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dietary interview</td>
<td>6 - 12</td>
</tr>
<tr>
<td>BMI</td>
<td>1</td>
</tr>
<tr>
<td>nPNA</td>
<td>1</td>
</tr>
<tr>
<td>Midweek predialysis creatinine</td>
<td>1</td>
</tr>
<tr>
<td>Serum albumin</td>
<td>1 - 3</td>
</tr>
<tr>
<td>Serum prealbumin</td>
<td>1 - 3</td>
</tr>
</tbody>
</table>

5. Nutritional requirements in PD patients

5.1 Energy requirements

Energy intake in PD patients represents the sum of dietary intake and the absorption of glucose from the dialysate. Metabolic balance studies of patients on chronic ambulatory peritoneal dialysis (CAPD), eating their usual diets, showed a strong correlation between total energy intake and nitrogen balance, irrespective of the duration of dialysis (19). A few studies have addressed the energy requirements of PD patients (19, 38). Based upon these studies, international panels of experts have made the following recommendations. ESPEN recommends an energy intake of 35 kcal/kg/day for PD patients, including glucose uptake from peritoneal fluid (39). NKF-KDOQI advocates an energy intake of 35 kcal/kg/day for patients younger than 60 years of age, and between 30-35 kcal/kg/day for patients older than 60 years of age (40). Finally, the European Best Practice Guidelines recommend, in their guidelines for nutrition in PD, an energy intake of 35 kcal/kg of weight/day for patients younger that 60 years-old and 30 kcal/kg of body weight/day for patients above 60 years-old (34). The resting energy expenditure of PD patients is similar to that of healthy, normal adults (38).

5.2 Protein requirements

Three nitrogen balance studies have been conducted in PD patients (19, 41, 42). These studies demonstrated that a positive or neutral nitrogen balance was obtained in relatively young patients eating 1.2 g/kg/day of protein. Based upon these studies, ESPEN recommended protein intakes of 1.2 to 1.5 g/kg/day, including at least 50% of high biological value proteins (39). T NKF-KDOQI recommends a protein intake of 1.2 to 1.3 g/kg of body weight/day for clinically stable PD patients (40) and the European Best Practice Guidelines advocates 1.3 g/kg/j (34).

It is noteworthy that in both HD and PD, metabolic balance studies have investigated a very small number of stable dialysis patients, over a short period. Whether lower energy and protein requirements are sufficient to maintain a positive or neutral nitrogen balance in some patients, for instance elderly patients or patients with little physical activity, is possible. In a recent study, Uribarri et al demonstrated, in 49 PD patients, that body weight, oedema-free/fat-free mass and anthropometric parameters could be maintained over a 6-month period on a total energy intake of 29 kcal/kg/day and a protein intake of 1 g/kg/day (43). However, these PD patients were relatively obese for their height, and when adjusted for the patients’ overweight condition, energy intake rose to recommended levels.

Energy and protein requirements in PD patients are summarized in Table 2.
Table 2 Recommendations for protein and energy supply in adult PD patients

<table>
<thead>
<tr>
<th></th>
<th>ESPEN</th>
<th>NKF-KDOQI</th>
<th>EBPG</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Protein intake, g/kg/day</strong></td>
<td>1.2-1.5 (&lt; 50 % HBV**)</td>
<td>1.2-1.3 (&gt; 50 % HBV**)</td>
<td>1.3</td>
</tr>
<tr>
<td><strong>Energy intake, kcal/kg/day</strong></td>
<td>35*</td>
<td>&lt; 60 y. 35</td>
<td>&lt; 60 y. 35*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt; 60 y. 30-35</td>
<td>&gt; 60 y. 30*</td>
</tr>
</tbody>
</table>

*Including energy supply (glucose) from PD fluids
**HBV: High biological value

ESSEN: European Society of Parenteral and Enteral Nutrition.
NKF: National Kidney Foundation.
EBPG: European Best Practice Guidelines

5.3 Mineral/Vitamins requirements

Studies investigating the mineral and vitamin requirements in PD patients are not available. Recommendations are similar to those for patients treated by HD. Losses of water-soluble vitamins through PD effluents suggest replacement of pyridoxine (10 mg) and vitamin C (100 mg) (Table 3).

Table 3: Mineral/Vitamins requirements of patients on PD

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td><strong>Phosphate, mg/d</strong></td>
<td>800 - 1000*</td>
<td></td>
</tr>
<tr>
<td><strong>Potassium, mg/g</strong></td>
<td>2000 - 2500*</td>
<td></td>
</tr>
<tr>
<td><strong>Sodium, g/d</strong></td>
<td>1.8 - 2.5*</td>
<td></td>
</tr>
<tr>
<td><strong>Fluid, ml</strong></td>
<td>1000 + urine volume</td>
<td></td>
</tr>
<tr>
<td><strong>Pyridoxin, mg</strong></td>
<td>10</td>
<td></td>
</tr>
<tr>
<td><strong>Vitamin C, mg</strong></td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

* Individual requirements may differ in acute conditions

6. Methods for nutritional support

Nutritional support in PD patients includes nutritional counselling, oral nutritional supplements (ONS), amino acid-based intraperitoneal parenteral nutrition (AA-IPPN), intravenous parenteral nutrition (IVPN) and tube feeding.

6.1 Nutritional counselling

In patients treated by HD, nutritional counselling improves compliance with nutritional recommendations. It is likely that this is also true for PD patients.

6.2 Oral nutritional supplements

Data regarding the use of ONS in PD patients are very limited and inconsistent. A small uncontrolled observational study of 10-weeks of oral protein supplementation failed to show an improvement in nutritional parameters in PD patients, although the compliant patients appeared to respond better (44). In a randomized clinical study including both HD and PD patients, a mixture of essential amino-acids (AA) improved nutritional status in HD, but not in PD patients (45). A six-month egg albumin-based supplementation improved nutritional status in a small randomized clinical trial in CAPD patients (46). Because of their usual lack of appetite and early satiety pattern, non-compliance may
limit the use of ONS in PD patients to a greater extent than in HD patients. The use of the intraperitoneal route to provide proteins in these patients therefore appears more appealing.

### 6.3 Amino acid intraperitoneal parenteral nutrition

AA-IPPN mainly consists in the intraperitoneal administration of 1.1% amino acid-based solution (47). Metabolic studies during intravenous infusion of $\text{^3H}_2$ and intraperitoneal leucine $\text{^{13}C}$ showed that intraperitoneal amino acids were incorporated in protein synthesis (48). The analysis of 11 studies of intraperitoneal AA infusions, including 4 randomized trials, showed an improvement in nitrogen balance and nutritional parameters in 4 cohort series (49). Intraperitoneal amino acids in non-acutely malnourished CAPD patients was reported to improve nitrogen balance, serum transferrin, and fasting morning plasma amino acid pattern (50). In a 3-year, randomized, prospective, controlled study, 60 CAPD patients were assigned randomly to either replace one exchange daily with AA dialysate or to continue with dextrose dialysates. Dietary protein intake increased in the AA group. Biochemical nutritional parameters including nPNA, albumin and cholesterol decreased in the dextrose group but remained stable or increased in the AA group. The nutritional benefit in the AA group appeared more prominent in women, whose lean body mass and body mass index were maintained in the AA group but not in the dextrose group. This study, however, did not show a significant effect of AA dialysate on patient survival (51).

In APD patients, data regarding this issue are very limited. A random-order short term cross-over study in 8 APD patients showed that the use of AA plus dextrose in dialysates improved rates of protein synthesis (L-[1-13C]leucine) and 24-h net protein balance, when compared to the use of dextrose only (52).

AA-IPPN may be associated with hypokalaemia and hypophosphataemia (47). Some patients may also develop mild acidaemia (53). These possible side effects underline the need for close monitoring during this treatment.

Based upon this evidence, AA-IPPN are recommended in stable PD patients, when nutritional requirements cannot be ensured by the oral or enteral routes.

### 6.4 Intravenous parenteral nutrition

IVPN has been poorly investigated in PD patients. ESPEN recommends a combination of carbohydrate and fat to address the energy supply (54). Specific formulae for parenteral solutions are not yet supported by controlled data in this setting. Present data suggests that intravenous IVPN should be limited to undernourished and stressed PD patients, or to patients with severe encapsulating peritonitis (54, 55), when nutritional requirements cannot be ensured by oral or enteral routes.

### 6.5 Tube feeding

In paediatric nephrology, small infants on PD are routinely tube fed. However, information regarding tube feeding in adult PD patients is not available. Clinical experience and common sense suggest that tube feeding may be recommended in two situations:

- If AA-based IPPN or ONS are insufficient to cover nutrition needs.
- In catabolic acute conditions in which neither oral intake nor AA-based IPPN are possible.

Although used in children treated by PD, percutaneous endoscopic gastrostomy or jejunostomy (PEG/PEJ) are not recommended in adult PD patients due to the risk of peritonitis (54).

### 7. Impact of nutrition support on outcome in PD patients

Demonstrating that adequate nutrition affects outcome in PD patients is an important challenge even though data from other conditions suggest intuitively that it may be of benefit. Studies to determine whether there is improvement in the morbidity and mortality of PD patients with these interventions are still needed and will require large multi-centre trials. AA-IPPN, and probably ONS, improve nutritional parameters in undernourished PD patients but their benefit in terms of improved patient survival is questioned. Only one prospective study addressed the effect of nutrition support on morbidity and mortality in PD patients. In this study, amino acid delivery through IPPN failed to reduce mortality and number of admissions to hospital compared to the control group over a three-year period (51). In HD patients, recent data have shown the
effectiveness of nutritional support in reducing morbidity and mortality in undernourished patients in which serum prealbumin improved (56). Although the same results could be expected in PD patients, no prospective data have demonstrated the effect of nutrition support on outcome in this group. Until these data become available, nutritional status must be assessed regularly in PD patients and nutritional treatment given as soon as malnutrition is detected.

8. Decision tree for nutritional support in PD patients

8.1 Non-acutely ill undernourished PD patients
Figure 1 gives a proposed decision tree.

![Decision Tree Diagram]

Figure 1 Proposed algorithm in undernourished PD patients

In patients with mild malnutrition, as defined by insufficient spontaneous food intake, dietary counselling must be given. If this is not sufficient, ONS may be prescribed, provided that the patient is compliant. But the evidence that ONS may improve nutritional status in this population is lacking. The use of AA-based IPPN is efficient at improving nutritional parameters. AA-based IPPN may therefore be preferred to ONS as a first choice option.

In patients with severe malnutrition and spontaneous intakes of more than 20 kcal/day, dietary counselling and IPPN are advocated; EN may be necessary if the above measures are unable to improve nutritional status.

In patients with severe malnutrition and spontaneous intakes less than 20 kcal/day, or in stress conditions, daily nutritional support is necessary. EN is preferred to IVPN. However, IVPN is indicated when EN is impossible or insufficient.

8.2 Acutely ill undernourished PD patients
The decision to use IVPN is the same as in patients with acute renal failure (54).
9. Perspectives to improve nutritional management in PD patients

It is likely that a multi-modal approach to malnutrition in PD patients, combining nutritional support with exercise and anabolic hormones may improve nutrition status to a greater extent than nutrition support alone. But this approach should be tested in randomised controlled trials.

Glucose load in PD patients is likely to be the cause of most of the metabolic disorders seen in these patients such as hyperglycaemia, hyperinsulinaemia (57), hyperleptinaemia (58) and insulin resistance (59). In addition, it is thought that glucose absorption may be responsible, at least in part, for fat accumulation in these patients. The development of strategies aimed at reducing glucose load using icodextrin, a glucose polymer PD fluid, has been shown to improve lipid profile and insulin resistance in these patients (60). Glucose exposure in PD regimen can be further reduced by replacing glucose-based PD fluids with both icodextrin and amino-acid based PD fluids during the same day. This combination may further improve the metabolic burden in these patients. Whether this will improve body composition, as well as nutritional parameters should be addressed in the future.

Summary

Nutritional support, preferably in the form of AA-IPPN, is able to improve nutritional status in PD patients. Whether morbidity and mortality can be reduced by nutritional support in these patients is unknown, although it is likely that it will, considering the positive data obtained in HD patients. The reduction in glucose load obtained by using glucose-sparing solutions improves the metabolic profile of PD patients, although the impact of these solutions on body composition and patient outcome is yet unknown.

References


