

Medical-nutrition therapy in polytraumatized patients: a race against time

Terapia médico-nutricional en pacientes politraumatizados: una carrera contra el tiempo

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Abstract

A polytraumatized patient is defined as one who has multiple lesions involving different organs and systems, which are usually serious and lead to life-threatening respiratory or circulatory dysfunction. Traumatic stress in the polytraumatized patient results in many metabolic changes that are evident from the first days, but usually persist for weeks, requiring adequate nutritional support as they influence outcomes. Nutritional treatment should be a priority in the comprehensive treatment of polytraumatized patients since it attenuates the metabolic response to trauma and prevents the deterioration of body reserves. It should be noted that some patients present previous nutritional risk. Nutritional intervention should be considered at the same level as any other therapy that supports organic functions, especially in patients in the intensive care unit. Nutritional intervention in polytraumatized patients is a pillar of treatment that has multiple benefits and can improve prognosis. All efforts must be aimed at the early detection of malnourished patients at nutritional risk and providing timely therapies that improve clinical outcomes.

Keywords: Polytraumatized patient. Nutritional risk. Enteral nutrition. Parenteral nutrition. Metabolic changes.

Resumen

El paciente politraumatizado se define como aquel que tiene múltiples lesiones que involucran diferentes órganos y sistemas, suelen ser graves y conllevan una disfunción respiratoria o circulatoria que pone en riesgo la vida. El estrés traumático en el paciente politraumatizado da lugar a muchos cambios metabólicos que son evidentes desde los primeros días, pero suelen persistir durante semanas y exigen un adecuado soporte nutricional, ya que influyen en los desenlaces. El tratamiento nutricional debe ser una prioridad en el tratamiento integral de los pacientes politraumatizados, porque atenúa la respuesta

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metabólica al trauma y evita el deterioro de las reservas corporales (cabe mencionar que algunos pacientes presentan riesgo nutricional previo). La intervención nutricional debe considerarse al mismo nivel que cualquier otra terapia que apoye las funciones orgánicas, sobre todo en pacientes en la unidad de terapia intensiva. La intervención nutricional en pacientes politraumatizados es un pilar en el tratamiento que tiene múltiples beneficios y puede mejorar el pronóstico. Todo esfuerzo debe ir encaminado a la detección temprana de pacientes desnutridos o en riesgo nutricional, y proporcionar de manera oportuna terapias que mejores los desenlaces clínicos.

Palabras clave: Paciente politraumatizado. Riesgo nutricional. Nutrición enteral. Nutrición parenteral. Cambios metabólicos.

Introduction

A polytraumatized patient is that who has multiple injuries involving different organs and systems, often severe and leading to life-threatening respiratory or circulatory dysfunction. The injuries often include spinal, cranioencephalic, thoracic, pelvic, abdominal, and limb traumas. A total of 80% of all deaths occur within 60 min after the injury, which is why health care professionals must undertake a series of coordinated measures for damage control, as well as to provide prompt care due to the high morbidity and mortality rates involved^{1,2}.

Traumatic stress in polytraumatized patients results in many metabolic changes that are evident from the early days but tend to go on for weeks, requiring proper nutritional support because they can impact the patient's outcomes. Patients who do not receive nutritional therapy within the first few first days after the injuries develop energy and nutrient deficiencies that contribute to an increased risk of complications such as infections and multiorgan failure^{3,4}.

Nutritional therapy should be a priority as part of the comprehensive management of polytraumatized patients, because it attenuates the metabolic response to trauma and stops the deterioration of reserves from the body (we should mention that some patients have prior nutritional risk). Nutritional intervention should be considered on the same level as any other therapy supporting organ functions at the intensive care unit (ICU) setting⁵⁻⁷. The objective of this review is to guide the process of nutritional support in polytraumatized patients to improve their prognosis and reduce the morbidity and mortality rates associated with this condition.

Epidemiology

Polytrauma is a non-natural cause of death worldwide, being one of the major causes for disability. In Mexico, it is considered a problem of public health

because accidents rank seventh in the overall mortality rate and are among the leading 9 causes of death across all age groups. Polytrauma ranks first in children aged 1 to 14 years and second in individuals aged 15 to 34 years. In 2018, a total of 34,589 accident-related deaths were reported, being the rate higher in men (75.8%)⁸. Back in 2017, the Global Burden of Disease report indicated that the disability-adjusted life years were 4042.79 per 10,000 inhabitants (16.04% overall) while the years lived with a disability were 422.45 per 10,000 inhabitants (4.42% overall)⁹.

Metabolic response to trauma

Traumatic stress triggers a series of stimuli that predisposes a response from the body in the process of restoring homeostasis or counteracting the threat. Trauma triggers metabolic, endocrine, hemodynamic, and immune responses that can go on for weeks and induce inflammatory and hormonal reactions that alter metabolic processes and, consequently, nutritional requirements¹⁰. The metabolic response to trauma has been defined in 3 phases whose characteristics are shown on table 1. It is mediated by catabolic hormones such as glucagon, catecholamines, corticosteroids, and insulin resistance, all of which increase after trauma and lead to increased mobilization of energy substrates¹¹. Amino acids (especially glutamine, alanine, and arginine) play a key role not only in the synthesis of acute-phase proteins but also in wound healing and in the successful recovery from injuries¹².

Nutritional state assessment

Patients with polytrauma should be nutritionally assessed upon admission to the ICU to identify those at nutritional risk who would benefit from nutritional support. Overall, these patients are not malnourished before sustaining the injuries, but all critically ill patients who stay in the ICU for over than 48 hours

Table 1. Phases of the metabolic response to trauma^{7,11,12,29}

Phase	Ebb phase	Flow phase	Anabolic phase
Other names	Shock phase, reflux, decay, or hypodynamic	Flow phase, hyperdynamic or catabolic	Repair or convalescence phase
Duration	Minutes to hours after the injury	Days to weeks after the injury, depending on severity	Weeks to months after the injury
Description	Immediate consequence of the injury resulting from fluid loss and characterized by efforts to protect homeostasis	Compensatory response to trauma and hypercatabolism	Occurs with prolonged maintenance of compensatory systems, depending on the severity of the injury
Characteristics	↓ Decreased cardiac output ↓ Decreased blood pressure ↓ Less circulating volume ↓ Lower body temperature ↓ Decreased urine nitrogen excretion ↓ Decreased insulin secretion ↓ Decreased basal metabolic rate ↓ Decreased glucose tolerance ↓ Increased hepatic gluconeogenesis ↑ Increased insulin resistance ↑ Increased hyperglycemia ↑ Increased sympathetic activity ↑ Increased catecholamines and cortisol ↑ Increased hepatic acute phase response ↑ Increased immune activation	↑ Increased metabolic stress ↑ Increased cardiac output ↑ Increased baseline metabolic rate ↑ Increased oxygen consumption ↑ Increased temperature ↑ Increased respiratory rate ↑ Increased proteolysis and lipolysis ↑ Increased insulin concentration ↑ Increased production and consumption of energy ↑ Increased negative nitrogen balance ↑ Increased hepatic gluconeogenesis ↑ Increased insulin resistance ↑ Increased hyperglycemia ↑ Increased catecholamines ↑ Increased systemic swelling (proinflammatory cytokines, activation of the complement system and immunosuppression)	↓ Decreased energy output ↑ Increased anabolism ↑ Increased gradual restoration of protein and lipid reservoirs ↑ Increased wound scarring, capillary growth, functional recovery and tissue remodeling Normalization of nitrogenated balance after stopping metabolic response to trauma

are at nutritional risk due to the hypermetabolic response to the injury and subsequent complications. A detailed medical history, including weight loss, physical examination, and body composition evaluation, should be collected^{4,5}.

Multiple tools can be used to assess nutritional status, such as the Subjective Global Assessment (SGA), the Malnutrition Universal Screening Tool (MUST), the Nutritional Risk Screening 2002 (NRS 2002), and the Nutrition Risk in the Critically Ill Score (NUTRIC). The latter two are the most widely used ones in these patients⁵. The NRS includes body mass index (BMI), weight loss, intake, and disease severity. Scores ≥ 3 are indicative of nutritional risk, while scores ≥ 5 are indicative of very high nutritional risk¹³. The NUTRIC scale identifies patients who would benefit from early enteral nutrition (EN) prescription. It considers age, severity as seen on the Acute Physiology and Chronic Health Evaluation II (APACHE II) and Sequential Organ Failure Assessment Score (SOFA) scores, comorbidity, length of stay prior to ICU admission, and optionally, inflammation indicated by interleukin 6 (IL-6) levels. Scores range from 0 to 10, and high scores (≥ 6 with IL-6 or ≥ 5 without IL-6) are associated with a high nutritional risk¹³. Regarding the diagnosis of

malnutrition, the criteria of the Global Leadership Initiative on Malnutrition (GLIM) should be used¹⁴.

While at the ICU, patients usually lose between 5% and 10% of their muscle mass per week, with losses reported of up to 1 kg/day due to increased proteolysis from the catabolic effects of stress, imbalance between intake and requirements, inactivity, bed rest, and immobility. Muscle mass can be measured using electrical bioimpedance, dual-energy x-ray absorptiometry or computed tomography. Supplementary measurements include calf and arm circumferences and dynamometry. Loss of muscle mass is associated with increased mortality and longer hospital stays, and it interferes with the patient's quality of life and functional capacity^{15,16}. The phase angle, obtained through electrical bioimpedance, has been proposed as an objective and non-invasive indicator of functional and nutritional health. Low values are indicative of cell membrane breakdown and, therefore, impaired energy storage and metabolic functions^{17,18}.

Serial measurements of acute-phase protein concentrations (C-reactive protein, fibrinogen, alpha-1-glycoprotein, etc.) along with constituent proteins (prealbumin, albumin, retinol-binding protein, transferrin) can improve the values of nitrogen balance as a

nutritional monitoring tool. Glucose should be closely monitored and maintained within a range of 140 mg/dL to 180 mg/dL. Electrolytes (potassium, magnesium, and phosphorus) should be measured at least once a week. In the presence of the refeeding syndrome, daily monitoring is advised^{5,6,16}.

Energy and protein requirements

Caloric and nutritional requirements, and the route of administration should be constantly monitored because they change depending on the patient's condition. The objective of meeting the requirements should be achieved progressively and preferably not before 48 hours to avoid overfeeding. Indirect calorimetry is the reference method to determine nutritional requirements. However, if unavailable, the carbon dioxide production from the ventilator with the Weir formula, and oxygen consumption from the pulmonary artery catheter with the Fick method can be used. Another practical method commonly used is to estimate calories per kilogram of weight per day (Table 2). Although predictive equations of energy expenditure can be used, they are ill-advised because they often under- or overestimate nutritional requirements by up to 60%.¹⁹ The calories from propofol and dextrose infusions should be included in the calculation since they are often sources of hidden and potentially excessive calories^{4-7,20}.

Polytraumatized should receive hyperproteic nutrition to support wound healing, increase the immune response, the accelerated protein synthesis, and hypercatabolism. The protein requirements recommended are 1.2-2.0 g/kg per day²⁰. In patients with an open abdomen, an additional 15-30 g of protein per liter of lost exudate is advised¹⁶. In obese patients¹⁶, 2.0 g/kg of ideal body weight per day is advised for patients with BMIs of 30-40 kg/m² or 2.5 g/kg of ideal body weight per day for those with BMIs $\geq$ 40 kg/m². The non-protein calories/grams of nitrogen ratio should be 80:1 to 120:1⁴.

Vitamins and trace elements must be a comprehensive part of enteral and parenteral nutritional support. Many micronutrients are severely depleted during the inflammatory response. Immediate supplementation—especially of water-soluble vitamins—reduces the risk of developing multiorgan failure. Selenium, zinc, and copper are essential for the anabolic phase after trauma. the administration of manganese should be cut down to 30-60 μ g/day. In critically ill patients with vitamin D deficiency (< 12.5 ng/mL), a high single dose is advised²¹.

Table 2. Caloric requirements in polytraumatized patients^{4-7,15,20}

Polytrauma with moderate-severe injuries (non-obese patients with ISS 25-30)	– 20-25 kcal/kg/day during acute and early phases – 25-30 kcal/kg/day (120% to 140% HB REE)
Polytrauma in obese patients	– 65% to 70% of the energy expenditure measured by indirect calorimetry – BMI = 30 to 50 kg/m²: 11-14 kcal/kg of actual body weight per day – BMI $\geq$ 50 kg/m²: 22-25 kcal/kg of ideal body weight per day
Severe cranioccephalic injuries (GCS < 8)	– Non-pharmacologically paralyzed patients: ~30 kcal/kg per day (140% HB REE) – Pharmacologically paralyzed patients: ~25 kcal/kg per day (100% HB REE)
Patients with spinal cord injuries	– Tetraplegics: 20-22 kcal/kg/day (55% to 90% Harris HB REE) – Paraplegics: 22-24 kcal/kg/day (80% to 90% HB REE)
Patients with burns	Multiple formulas can be used depending on the body surface area damaged; the Curreri formula is one of the commonly used ones but tends to make 25% to 50% overestimations or else the HB formula multiplied by a stress and activity factor.

BMI: body mass index; GCS: Glasgow Coma Scale; HB: Harris Benedict formula; ISS: Injury Severity Score; REE: resting energy expenditure.

Enteral nutrition

The provision of exogenous substrates when demand is increased due to the hypercatabolic state improves the clinical outcomes. Most patients with severe injuries who are expected to survive 24 to 48 hours will probably have long stays at the ICU and remain at risk of infection, acute respiratory distress syndrome, multiple organ dysfunction, and even death. Nutritional support should be considered in all patients with intolerance to oral intake 72 hours after the event or with multiple interruptions due to medical procedures²¹. The main goal of nutritional treatment is to maintain immune defenses by supporting hypercatabolism and preserving muscle mass⁶.

Early EN should be the first-line therapy for nutritional support in polytraumatized patients. It is a safe route of administration that can be used in most of these patients once the fluid resuscitation phase has been completed and hemodynamic stability has been achieved²². The European Society for Clinical Nutrition and Metabolism (ESPEN) defines early EN as feeding within the first 24 to 48 hours after ICU admission;5 during this time, there is a therapeutic

window where nutritional support can positively impact the outcomes and improve GI tolerance²³.

Early EN is recommended because it spares the anatomical and functional integrity of intestinal mucosa and gut-associated lymphoid tissue (GALT), maintains the immune response, reduces oxidative stress, the risk of infections, the length of stay, mortality, the development of multiple organ failure, the rate of intra-abdominal abscesses, and episodes of ventilator-associated pneumonia eventually improving the clinical outcomes. For EN to provide these benefits, at least, 50% to 65% of the total energy expenditure (TEE) should be administered²³⁻²⁵.

EN is contraindicated in patients who have not been fully resuscitated, remain hemodynamic unstable, have uncontrolled shock, hypoxemia, hypercapnia or uncontrolled acidosis, require high doses of inotropic and vasopressor support, have GI bleeding, gastric residual volume ≥ 500 mL/6 h, intestinal discontinuity, mesenteric ischemia, ileus, polytrauma with significant retroperitoneal hematoma and peritonitis, intestinal obstruction, abdominal compartment syndrome, and high-output fistulas. Under these conditions, starting parenteral nutrition (PN) is advised^{19,23}.

EN should be initiated at gastric level, often through a nasogastric or orogastric tube (indicated in patients with severe injuries in the facial, maxillary, and basal frontal areas). Gastric tolerance should be monitored on a daily basis. Gastric intolerance is characterized by abdominal distension, vomiting, risk of bronchoaspiration, high gastric residual volume, or failure to achieve, at least 50%, of the target values within 48 hours. However, if tolerance is not achieved with the use of prokinetics (metoclopramide or erythromycin), with the transition to strategies such as continuous infusion, or when gastric feeding is contraindicated, the tube should be placed at jejunal level. In patients with traumatic brain injury, septic complications, burns or certain drug-related adverse events, the presence of gastroparesis should be assessed because, in these cases, gastric feeding is contraindicated²⁶.

In patients requiring prolonged nutritional support, the placement of enteral devices (gastrostomy) should be considered, such as in patients with severe brain injuries. They are, however, contraindicated in patients with an open abdomen if the intestine is fragile, swollen or edematous. Jejunostomy is ill-advised as the first method for EN. It is indicated in patients with pancreaticoduodenal, esophageal, gastric, or duodenal injuries in which EN will be required for an extended period, with gastric access being contraindicated here²⁶.

Careful gradual reintroduction of nutrition reduces the risk of the refeeding syndrome in patients with severe malnutrition or low intake prior to admission. Once the patient has been stabilized, hypocaloric EN ($< 70\%$ of TEE) can be started with continuous infusion or bolus feeding and a low infusion rate (10 mL/h to 40 mL/h) with trophic effects on the intestinal mucosa⁵. The feeding rate can be increased by 10 mL/h to 25 mL/h every 8 to 12 hours to reach the target in the absence of intolerance²⁷. Progression to achieve the goal set can be slower in patients with abdominal trauma index scores ≥ 40.6 . Patients at high nutritional risk or with severe malnutrition should reach their caloric goals within the first 24 to 48 hours, always observing the risk of the refeeding syndrome. Efforts should be made to provide $> 70\%$ (estimated energy) or $> 80\%$ (measured energy) of the energy and protein goals within 72 hours to achieve the clinical benefits of EN within the first week of hospitalization (Fig. 1)¹⁶.

Standard polymeric formulas of 1.0 kcal/mL to start EN are advised, preferably high in proteins. However, in patients requiring volume restriction, formulas with a caloric density of 1.5-2.0 kcal/mL are advised. Additionally, the use of specialized formulas low in carbohydrates for patients with diabetes improves the glycemic profile. Carbohydrate requirements should be individualized based on the patient's blood glucose levels and glucose intolerance^{16,20}.

The use of immunomodulatory formulas with arginine, nucleotides, and omega-3 is also indicated in patients with trauma, acute respiratory distress syndrome or moderate, non-severe sepsis (APACHE II < 15). The administration of these formulas to critically injured polytraumatized patients for 7 to 10 days has been reported to reduce infection rates, complications, antibiotic use, the risk of multiple organ failure, and the length of stay, and increase survival^{16,22}.

Despite being the most abundant amino acid in the body, glutamine is depleted during trauma-related stress. It is the primary energy source for rapidly dividing cells such as enterocytes, lymphocytes, macrophages, bone marrow cells, endothelial cells, and proliferating cells in wounds and swollen regions. Glutamine should be added to standard formulas in all patients sustaining traumas and burns. Doses of 0.2 to 0.3 g/kg/day within the first 5 days of EN can be used. This course can be extended for up to 10 to 15 days. For patients with $> 20\%$ total body surface area burned, 0.3 to 0.5 g/kg/day is advised for 10-15 days at the beginning of EN²⁸.

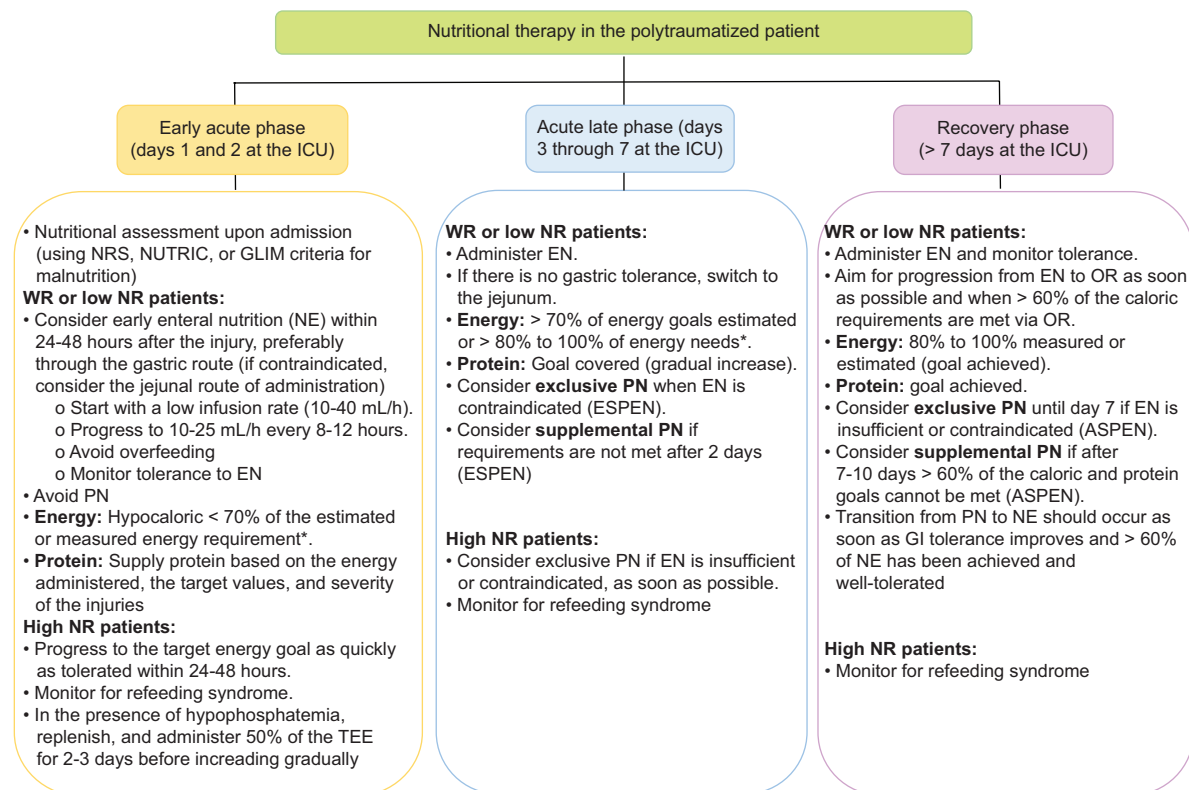


Figure 1. Nutritional treatment synthesis in polytraumatized patients. ASPEN: American Society for Parenteral and Enteral Nutrition; EN: enteral nutrition; ESPEN: European Society for Clinical Nutrition and Metabolism; GLIM: Global Leadership Initiative on Malnutrition; ICU: intensive care unit; NR: nutritional risk; NRS: Nutritional Risk Screening 2002; NUTRIC: Nutrition Risk in the Critically Ill Score; OR: oral route; PN: parenteral nutrition; WR: without risk.

*Energy estimated using formulas or measured using indirect calorimetry.

Parenteral nutrition

Although EN has fewer complications, PN is an essential and vital treatment to provide nutritional substrates to patients without functional GI tracts.²⁸ In some cases, EN may not be feasible, either because it is not fully tolerated within the first week at the ICU, due to contraindications (such as intestinal failure or high-output enterocutaneous fistulas) or because it cannot provide the proper nutrients according to the body's demand. In such situations, the use of PN is advised. However, PN should not be started until all the strategies mentioned before have been tried to maximize tolerance to EN^{19,20}. In cases treated with PN, transition to EN should be made after GI tolerance has improved, when EN can account for > 60% of the TEE and is well-tolerated.

In polytraumatized patients with or without low nutritional risk, exclusive PN should be avoided until day 7 in cases when proper intake cannot be maintained or EN is not feasible according to the

guidelines of the American Society for Parenteral and Enteral Nutrition (ASPEN).¹⁶ On the other hand, ESPEN guidelines propose that PN should be administered within the first 3-7 days to patients in whom EN is contraindicated or not tolerated⁵. Contraindications for PN include the possibility of enteral feeding, severe hemodynamic instability, and metabolic changes¹⁹.

Exclusive, low-dose PN can be administered as soon as possible after the ICU admission if there is high nutritional risk or severe malnutrition, and when EN is not feasible, always considering that the risk of refeeding syndrome can outweigh the expected benefits. Hypocaloric nutrition and proper doses of proteins can be gradually administered based on the patient's clinical status during the first week at the ICU. Overall, PN is administered through a central venous catheter that supports high-osmolarity emulsions that cover the total nutritional requirements, unlike peripheral PN^{15,16,19}.

PN can be administered independently or together with EN to improve energy and nutrient delivery.

Therefore, in low or high nutritional risk patients, the use of supplemental PN is advised after 7-10 days if > 60% of energy and protein requirements cannot be met via enteral route, as per the ASPEN guidelines¹⁶. The ESPEN guidelines propose that all patients receiving less than the target intake after 2 days should be considered for supplemental PN⁵. Initiating supplemental PN before this time does not improve the outcomes and may be detrimental to the patient increasing the risk of infections. It is recommended to use both routes concomitantly, whenever feasible, to reduce the risk of hyperglycemia, hepatocellular damage, immunosuppression, and GALT dysfunction^{24,25}.

Complications associated with PN include access, mechanical issues, infections, and metabolic concerns¹⁵. Concerns during glucose administration and hyperglycemia are particularly relevant for patients receiving PN. Monitoring blood glucose levels and paying careful attention to infusion rates is of paramount importance, because it is a common thing to mistakenly administer excessive glucose and calories intravenously for a short period of time, which triggering complications²⁰.

IV lipid emulsions with long-chain, medium-chain triglycerides or a combination of the two can be safely administered at a rate of 0.7 g/kg up to 1.5 g/kg for 12-24 hours^{5,6}. Soy-based lipid emulsions should be restricted or limited to 100 g/week (divided into two doses) in critically ill patients if there are concerns of potential essential fatty acid deficiency. Olive oil-derived emulsions are a neutral source of essential fatty acids and contain a low amount of omega-6. Fish oil-based emulsions have effects on the cellular membranes and anti-inflammatory processes and are associated with fewer infections, shorter courses of mechanical ventilation, and fewer days at the hospital¹⁶. Some studies have reported that the complete limitation or minimal administration of lipids in polytraumatized patients during the acute phase of the injury can minimize susceptibility to infections and reduce the length of stay^{28,29}.

Within PN, carbohydrate administration should not exceed 5 mg/kg/min and be adapted to each patient's tolerance. The minimum requirements are 2 g/kg/day, and 150 g/day is advised to maintain the preference of certain organs for glucose, such as brain, erythrocytes, immune cells, and kidneys. Excess glucose intake is associated with overfeeding, hyperglycemia, increased carbon dioxide production, lipogenesis, and insulin requirements.^{5,6} The amino acid solution should contain 0.2-0.4 g/kg/day of L-glutamine or 0.3-0.6 g/kg/day of alanyl-glutamine dipeptide^{5,29}.

Conclusions

Nutritional intervention in polytraumatized patients is an essential pillar to improve prognosis and obtain multiple benefits. Many of these patients cannot be fed orally due to the severity of their injuries, making nutritional support essential for their recovery. It is important to conduct nutritional assessments upon admission to determine what the appropriate approach should be. Early EN is the preferred approach in patients with a functional GI tract. However, if enteral access is not possible or nutritional requirements cannot be fully met, PN should be used. In malnourished patients, early and progressive PN is recommended as soon as possible to avoid periods of fasting. PN should also be used in cases where EN is contraindicated. It is crucial to avoid overfeeding and the refeeding syndrome when administering EN and PN. Therefore, nutritional goals should be achieved gradually and adjusted daily based on the patient's tolerance and biochemical parameters. Overall, continuous monitoring of the patient's enteral tolerance and biochemical parameters along with daily follow-ups are important to make sure that nutritional goals are met and contribute to a more successful recovery.

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Conflicts of interest

None reported.

Ethical disclosures

Protection of human subjects and animals in research. The authors declare that no experiments were performed on humans or animals for this study.

Patients' data protection. The authors declare that no patient data appear in this article.

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