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Nutritional and Metabolic Status Control and Nutritional Support in Patients with Pancreatic Sepsis (Review)

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Summary

Acute pancreatitis (AP) is associated with pancreonecrosis in 30% of patients, who may fall at 80% high risk of death when infected pancreatic necrosis progresses to sepsis. Given the catabolic nature of the disease and the significant influence of nutritional status on its course and outcome, these patients require an adequate nutritional support (NS) based on an adequate assessment and control of nutritional and metabolic status.

The aim of the study: to identify trends in developing new tools for assessment of nutritional and metabolic status, and provision of NS in patients with pancreatic sepsis (PS).

Materials and methods. Keyword search in the PubMed, Scopus and E-library databases for the period from 2018 to 2023 yielded 95 publications, of which 16 meta-analyses and 6 systematic reviews met the requirements.

Results. all existing to date scales for assessment of nutritional deficiency in patients with PS have low prognostic value. Of them, mNUTRIC scale seems to be the most appropriate assessment tool. Recommended by EPSEN guidelines tools to assess the risk of nutritional deficiency it is not suitable for ICU patients. Indirect calorimetry should be preferred vs routine calculation formulas in assessing patient's energy needs in case of PS. It was also found that «standard» anthropometric values, such as BMI, are not always informative and prognostically significant in patients with severe AP in the ICU. Analgesia, infusion therapy, as well as detection and correction of intraperitoneal hypertension are not only integral components of intensive care for PS but are indispensable for supplying adequate NS in PS patients. It was found that early enteral nutrition is the preferred method of NS, although questions concerning choice of tube insertion site, as well as all parameters of tube feeding remain unanswered. The optimal composition of enteral nutrition for patients with PS has not been established, which is indirectly confirmed by the variety of enteral mixtures available on the market. The refeeding syndrome that occurs at initiation of NS was characterized as a life-threatening condition.

Conclusion. NS, based on adequate assessment of disorders and control of the nutritional and metabolic status is an integral component of intensive care in PS patients. It can reduce the probability and number of potential complications, time of stay in the ICU, cost of treatment, and improve patient's prognosis.

Keywords: nutritional and metabolic status; nutritional support; pancreatic sepsis; sepsis; acute pancreatitis, pancreonecrosis.

Conflict of interest. The authors declare no conflict of interest.

Introduction

The prognosis and progression of critical illness, including pancreatogenic sepsis, are significantly influenced by the life support systems that maintain homeostasis. It is essential to recognize that the pancreas, through its exocrine and endocrine functions, plays a critical role in maintaining the body homeostasis by participating in digestion and metabolism. Disruption of these processes can lead to the development of severe nutritional and metabolic deficiencies, resulting in the hypermetabolism/hypercatabolism syndrome. This syndrome is characterized by increased energy intake and nitrogen losses, as well as a significant decrease in total plasma protein levels with severe hypoalbuminemia [1, 2]. This syndrome is common in many critical conditions, but has specific features in severe acute pancreatitis. It is associated with the catabolic nature of the disease, the specificity of its pathogenesis, the need for extensive surgical intervention, and the rapid development of sepsis, which further increases catabolism and the body's energy requirements, worsening the course and prognosis of the disease [3, 4].

Intensive therapy for pancreatogenic sepsis should focus on supporting the vital functions of the body, which deteriorate due to the development of multiple organ failure syndrome. Special attention should be paid to nutritional deficiencies, which are often underestimated in the management of this condition.

Nutritional support (NS) is not only about providing nutrition to patients, but also includes a range of measures aimed at maintaining trophic

homeostasis, optimizing structural, functional and metabolic processes, and preserving adaptive reserves [5]. It can also be seen as a tool for managing the systemic inflammatory syndrome, reducing the number of complications, and modifying the course of the disease [6,7]. Insufficient NS in acute pancreatitis and other surgical abdominal diseases can have negative effects on the cellular and humoral components of immunity, leading to a decrease in the body's non-specific reactivity, slower healing processes, and the development and progression of enteral insufficiency syndrome, which is a crucial element in the pathogenesis of infected pancreatic necrosis [8,9].

The aim of this article was to identify patterns in the development of diagnostic techniques for nutritional and metabolic status and management of NS in patients with pancreatogenic sepsis.

Materials and Methods

To obtain a comprehensive overview of the current scientific knowledge, a thorough search was performed using 3 databases, namely PubMed, Scopus, and Elibrary, from 2018 to 2023. The keywords used for the search were acute pancreatitis, infected pancreatic necrosis, sepsis, nutritional support, metabolism, and indirect calorimetry. The search yielded 95 eligible articles, including 16 meta-analyses and 6 systematic reviews that met the inclusion criteria. The category restriction was set to randomized clinical trials and reviews in patient groups younger than 18 years and older than 60 years. The inclusion criteria for the review were based on design (clinical trials published in international peer-reviewed journals without language or national restrictions) and subjects (adult patients with pancreatic necrosis and sepsis). The authors extracted data from the selected articles, including the author's first and last name, journal name, country, and year of publication.

Results of the Study

The initial search yielded 486 articles, of which 52 were in Russian and 434 were in English. After excluding articles that did not meet the search criteria, 133 articles remained, from which clinical observations and articles that did not meet the inclusion criteria were again excluded. A total of 95 articles were included in the systematic review, comprising 16 meta-analyses and 6 eligible systematic reviews. The source selection algorithm is shown in the figure.

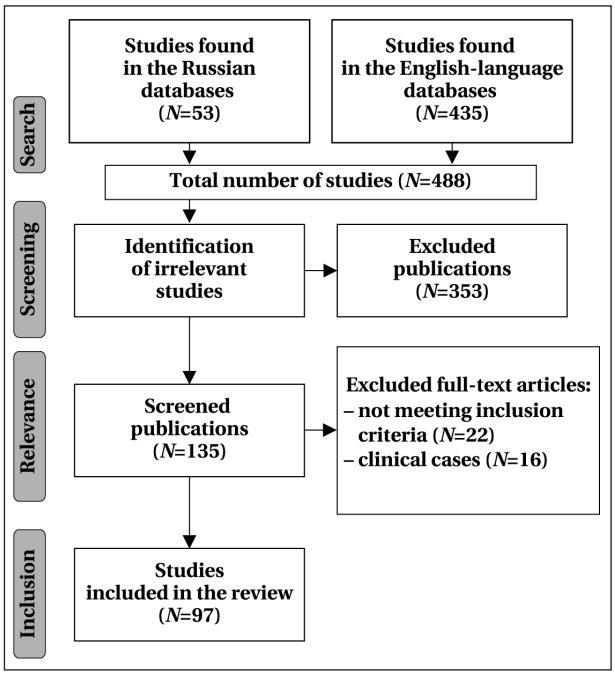

Fig. Flowchart of the source selection.

Indices and scales. Rational and timely monitoring of nutritional and metabolic status is an important aspect of intensive therapy of pancreatogenic sepsis in the ICU. To date, there are no uniform algorithms and protocols for monitoring the nutritional and metabolic status of patients with severe acute pancreatitis (AP). However, there are a large number of different indices and scales to assess the risk and severity of nutritional deficiency in critically ill patients, although no index or scale has shown its prognostic value in surgical patients in the ICU [10, 11]. In a study based on the analysis of the nutritional status of 120 critically ill patients, the NRS-2002 was shown to have the highest sensitivity and specificity among all scales for the detection of nutritional risk [12, 13]. In another study, it was found that the prognostic significance of such popular scales for assessing the severity of nutritional deficiency in surgical patients as NRS-2002, MUST, MNA-SF is still unclear, and the most appropriate scale, despite its lower specificity but comparable in strength of prognostic ability to APACHE-II and SOFA scales, is the mNUTRIC scale [14, 15]. However, to date, no studies have determined its prognostic value in patients with pancreatogenic sepsis. Large-scale studies are needed to determine appropriate scales to assess the severity of nutritional deficiencies in this patient population based on compliance with the requirements of practical medicine, including ease of use and interpretation of results, informativeness, and reliability and validity confirmed by studies conducted in clinical settings [16, 17].

Notably, ESPEN recommendations state that all critically ill patients (including those with severe AP) admitted to the ICU should initially be considered at high risk of malnutrition, which means that the use of prognostic indices to identify the risk of malnutrition is currently inappropriate [18].

Indirect calorimetry (metabolography). Indirect calorimetry is a valuable tool for studying nutritional and metabolic disorders in patients

suffering from various diseases. It is based on the determination of a patient's current energy requirements based on the simultaneous measurement of oxygen consumption (VO_2) and carbon dioxide elimination (VCO_2) during spontaneous breathing or lung ventilation [19]. In addition, this method allows real-time calculation of a patient's energy requirements and assessment of nutrient metabolic pathways, both of which are critical in planning nutritional and metabolic support for critically ill patients [20].

Patients with severe AP have higher resting energy requirements than healthy individuals because they develop septic complications and a marked hypermetabolism/hypercatabolism syndrome. The randomized TICACOS trial demonstrated improved survival with daily metabolographic monitoring of patient energy requirements and appropriate daily adjustment of NS composition [21, 22].

Indirect calorimetry can measure a patient's energy requirements much more accurately than calculated formulas, preventing both over- and undernutrition and identifying indications for supplemental parenteral nutrition or, conversely, avoiding unnecessary prescriptions [23, 24]. However, the use of this method is limited for a variety of reasons, including the high cost of the necessary equipment, insufficient training of physicians in clinical nutrition, and a lack of medical literature on the use of indirect calorimetry in critically ill patients [25]. Certain limitations in the use of indirect calorimetry in the ICU contribute to the continued use of outdated equations in clinical practice, the prognostic value of which is increasingly questioned [26].

Anthropometry. Anthropometry is a non-invasive and relatively straightforward research method that involves measuring the basic parameters of the human body and its components. Anthropometric methods include the measurement of height and weight, BMI, subcutaneous fat thickness, upper arm circumference, and other human parameters that provide the practitioner with some insight into the patient's condition. However, it remains unclear which of these parameters are the most informative and can be used to assess the severity of nutritional deficiency in patients with pancreatogenic sepsis [27]. For example, the commonly used body mass index may not be an effective indicator for assessing nutritional deficiency due to various factors such as fluid therapy, diuresis, and other fluid losses [28]. Therefore, large randomized trials are needed to determine the predictive and prognostic value of different anthropometric parameters in patients with nutritional deficiencies.

Intra-abdominal hypertension. Multiple organ failure developing in infected pancreatic necrosis can be caused by progression of septic complications as well as intra-abdominal hypertension resulting in abdominal compartment syndrome, which is a serious and potentially fatal complication in surgery and intensive care [29]. Destructive acute pancreatitis is a major cause of abdominal compartment syndrome [30, 31]. Other factors causing intra-abdominal hypertension include intestinal paresis, duodenal compression, gastric stasis, and the presence of free fluid in the abdominal cavity and retroperitoneum due to enzyme-containing effusion, abdominal wall stiffness due to edema, and inadequate analgesia [32]. It is important to note that the intestinal failure syndrome, which is a consequence of intestinal paresis in these patients, plays an important and sometimes critical role in the pathogenesis of intra-abdominal hypertension. Therefore, it is essential to develop an adequate approach to correct intestinal paresis in patients with severe AP complicated by sepsis. This approach is necessary to address several issues simultaneously, such as the progression of the intestinal failure syndrome, the development of intra-abdominal hypertension, continuous translocation of intestinal flora into the bloodstream, and ischemic injury to the intestinal mucosa with dystrophic changes in the epithelium, which can lead to dangerous complications such as intestinal perforation and peritonitis [33–35].

Intra-abdominal hypertension affects many systems of the body, including the cardiovascular, urinary, and respiratory systems, but the organs of the digestive tract are of particular interest because of their role in the pathological process and the development of changes prior to clinically detectable signs of abdominal compartment syndrome. Inadequate fluid therapy with underlying heart failure and renal dysfunction further exacerbates the process, and the emerging and rapidly progressing intestinal mucosal edema and paresis lead to a disruption of intestinal barrier function with continued translocation of intestinal flora into the abdominal cavity and systemic blood flow, closing the «vicious circle». This requires a radical change in the strategy of nutritional and metabolic support and control of intra-abdominal hypertension. Further large-scale studies are needed to identify the most effective methods to reduce the severity of intra-abdominal hypertension and to establish clear indications for switching from enteral to parenteral nutrition and vice versa in patients with pancreatogenic sepsis in the ICU. Patients with pancreatogenic sepsis and intra-abdominal hypertension are more likely to have increased energy requirements due to decreased intestinal perfusion, acidosis, or bacterial translocation.

Analgesia. Adequate analgesia is one of the most important components of intensive care for severe acute pancreatitis. A recent systematic review and meta-analysis aimed to compare the efficacy of different methods of analgesia in acute

pancreatitis [36]. Despite its infrequent use, epidural analgesia has been shown to be more effective than medication and should be considered as an alternative or as a component of combined analgesia when used with analgesics in a multimodal approach [37, 38].

Thoracic epidural anesthesia is particularly attractive from the point of view of nutritional and metabolic support and intensive care for several reasons.

First, the early use of prolonged epidural anesthesia in patients with severe AP, in addition to its analgesic effect, also has an enteroprotective effect, which is beneficial for the treatment of intestinal paresis and prevention of abdominal compartment syndrome, which in turn significantly affects the nutritional and metabolic support strategy [39].

Second, thoracic epidural anesthesia can block afferent stimuli that serve as triggers for the development of endocrine and metabolic responses to stress, indirectly reducing the intensity of catabolism.

Third, with adequate fluid therapy, thoracic epidural anesthesia improves splanchnic blood flow, thereby reducing the clinical manifestations of acute pancreatitis.

Fluid therapy. Organ and system injury in severe acute pancreatitis is primarily the result of intoxication and hypovolemia. Adequate fluid therapy is the only treatment for this disease that has been associated with a reduction in mortality in large studies over the past decade [40]. According to some authors, the blood supply to the pancreas can decrease by more than 70% immediately after the first manifestations of acute pancreatitis [41]. In addition, hypovolemia leads to hypoperfusion of all internal organs, resulting in progression of intestinal paresis and enteral failure syndrome with further impairment of intestinal barrier function, progression of infectious complications and multiple organ failure syndrome [42]. According to experts, an infusion started on the first day of the disease may prevent or reduce damage to the pancreas by maintaining a minimally adequate microcirculation [43]. In particular, adequate fluid therapy should precede nutritional support, which is ineffective in the presence of signs of dehydration in patients with severe AP.

Data regarding the fluid volume required for infected pancreatic necrosis are conflicting. The benefit of goal-directed fluid therapy in acute pancreatitis (reduction of heart rate below 120/min, achievement of mean arterial pressure of 65–85 mm Hg, restoration of diuresis to 0.5–1.0 mL/kg/h) remains unproven. Hematocrit, lactate, urea, and creatinine may be considered laboratory markers of volume status and adequate tissue perfusion; therefore, their serial measurement is recommended [44]. The determination of splanchnic blood flow in the pancreas can be used to assess the efficacy of fluid therapy, but studies on the use of pancreatic Doppler imaging as a prognostic marker of the severity of acute pancreatitis and as a method to assess the efficacy of treatment are extremely limited.

Enteral or Parenteral Nutrition? For a long time, parenteral nutrition was preferred in patients with severe AP, despite the high risk of catheter-associated infections, electrolyte disturbances, progression of multiple organ failure syndrome, and high cost of parenteral nutrition drugs [45–47]. The use of this type of NS allowed «pancreatic rest» and reduced the intensity of its exocrine secretion, thus minimizing the local inflammatory response caused by enzymatic aggression [48, 49].

New knowledge about the role of intestinal nutrition in the pathophysiology of acute pancreatitis has changed the approach to the principles of intensive therapy for this disease [50]. The results of meta-analyses conducted over the last decade, including a different number of randomized controlled trials with different numbers of participants, clearly showed the advantages of enteral nutrition over parenteral nutrition in terms of the incidence of complications (infectious and non-infectious), need for surgical intervention, progression of multiple organ failure syndrome, and mortality [51–53].

A 2018 meta-analysis of 5 RCTs (348 patients) showed that the use of enteral nutrition was associated with a significant reduction in mortality, RR 0.36 (95% CI: 0.20–0.65), and the incidence of organ dysfunction, RR 0.39 (95% CI: 0.21–0.73), compared with parenteral nutrition [52]. These differences were confirmed in a recent meta-analysis of 11 studies, involving 562 patients. The results showed that enteral nutrition significantly reduced mortality (RR=0.43; 95% CI: 0.23–0.78), risk of complications (RR=0.53; 95% CI: 0.39–0.71), and length of hospital stay (mean difference=–2.93, 95% CI: –4.52 to –1.34) [53].

The American Association of Clinical Nutrition and Metabolism ASPEN recommends the use of parenteral nutrition only when enteral nutrition is not possible or cannot meet the minimum caloric requirements of the body [54].

Specific indications and contraindications for the administration of enteral and parenteral nutrition should be considered when providing nutritional and metabolic support to patients with pancreatogenic sepsis.

Early enteral nutrition. The timing of NS initiation is a key point in the management of patients with AP, including those with infected pancreatic necrosis. The concept of «pancreatic rest» has been popular since the 1970s [55, 56]. This concept states that enteral nutrition should be initiated only after complete relief of abdominal pain and normalization of blood pancreatic enzyme levels. Based on the

concept of minimizing pancreatic stimulation, parenteral nutrition and its gradual expansion, starting with clear liquids, have been used. However, this concept is based only on speculation, has no reliable evidence base, and its implementation may lead to worsening of the patient's condition and increase the risk of developing an unfavorable outcome.

In contrast, the popularity of early enteral nutrition is «gaining momentum» worldwide, and not by chance [57]. The American Gastroenterological Association guidelines, published in 2013 and updated in 2018, recommend early (within the first 24 hours) enteral nutrition for acute pancreatitis [58–61]. This recommendation is supported by a meta-analysis of five large randomized controlled trials, the results of which clearly demonstrate the benefits of early enteral nutrition through positive effects on the structure and function of the intestinal epithelial layer, which inhibits the translocation of intestinal flora into the systemic bloodstream and internal organs [62,63].

A 2018 systematic review evaluating the results of 10 randomized controlled trials showed that in infected pancreatic necrosis, initiation of enteral nutrition within the first 48 hours resulted in less progression of systemic inflammatory response and multiple organ failure, need for surgical intervention, and mortality compared with delayed enteral or parenteral nutrition [64, 65].

Enteral formulas. Most studies on the clinical benefits of early enteral nutrition have used semi-elemental enteral formulas, while more recent studies have used standard polymeric formulas. All the studies demonstrated the feasibility of using both elemental enteral formulas in patients with pancreatitis.

In a small RCT of 30 patients, both formulas were found to be safe and well tolerated. Visual analog scale parameters and number of bowel movements per day were evaluated. Some clinical advantages of semi-elemental enteral formulas were found, including a shorter ICU stay (23±2 vs. 27±1 days, P=0.006) and no weight loss [66].

Another meta-analysis involving 428 patients showed no differences in the incidence of infection and mortality between patients receiving formulas with different elemental compositions [67].

A more recent meta-analysis of 15 RCTs (1376 participants) showed no benefit from any specific enteral formula [68].

Nevertheless, it is clear that patients with severe AP are at a high risk of malabsorption; therefore, semi-elemental enteral formulas may be of great interest. Given the wide variety of enteral formulas available in the market, further large randomized clinical trials are needed to identify the optimal enteral formulation for patients with pancreatogenic sepsis.

Routes of enteral nutrition administration. There are no definitive answers in the literature as to which method of enteral nutrition delivery is most effective, has a lower risk of complications such as induction of local inflammation, and is preferable for use at any given time during the course of the disease.

Based on a 2014 multicenter randomized trial in patients with pancreatitis, no advantage was found for enteral feeding via nasogastric tube in the first 24 hours of illness compared to oral feeding 72 hours after the onset of illness. This study included only 205 patients, which limited the power to detect a significant difference between the study groups. In addition, one-third of patients required enteral nutrition via nasogastric tube because of lung ventilation or intolerance to oral nutrition.

According to the scientific literature, the small intestine has long been the preferred site for tube placement. Enteral nutrition delivered to the GI tract proximal to the ligament of Treitz stimulates pancreatic enzyme secretion [69, 70]. Traditionally, this has been thought to lead to increased pancreatic autolysis and further progression of acute pancreatitis. There is experimental and clinical evidence that exocrine pancreatic secretion is not stimulated when enteral nutrition is administered into the duodenum distal to the ligament of Treitz. Such a route of administration can be easily accomplished in the current context by endoscopic methods or intraoperatively. In addition, several studies have shown that nasojejunal administration results in a significantly higher volume of absorbed nutrition than nasogastric administration [71]. This method of administration has advantages in patients with severe AP due to impaired gastric motility, with the degree of delayed gastric emptying increasing with disease severity.

The underlying mechanism of these abnormalities is primary gastric motility dysfunction with impaired proximal and distal gastric coordination as a result of hormonal imbalance. A recent meta-analysis comparing the efficacy of nasogastric and nasojejunal delivery of enteral nutrition in 131 patients found no differences in safety, efficacy, or mortality.

Another meta-analysis of 220 patients fed via nasogastric or nasointestinal tube also found no significant difference between groups in mortality, incidence of complications (infectious and non-infectious), diarrhea and need for surgery, severity of pain, food intolerance, and severity of protein-energy deficiency syndrome. A large multicenter trial, which was discontinued due to the inability to recruit participants, was designed to help select the preferred method of enteral nutrition administration [72].

It is believed that if prolonged (30 days or more) nasoenteral nutrition is required, alternative routes of administration should be considered, as

prolonged tube placement can lead to complications such as nasopharyngeal trauma, sinusitis, tube displacement and removal, «silent» aspiration, etc. [71]. Gastrostomy, jejunostomy, or gastrojejunostomy may be used as an alternative route for enzyme administration, but research on their efficacy in severe acute pancreatitis is limited.

Rate of nutrient delivery. It is important to note that the rationale for enteral NS in patients with severe AP depends on the rate of enteral formula delivery, the mode of administration (continuous infusion, cyclic, or bolus), and the initial volume of enteral nutrition.

Despite the paucity of scientific papers on this topic, current clinical guidelines recommend the use of continuous feeding because of its better tolerability [73]. They also state that patients in the ICU should not receive energy in amounts corresponding to metabolic needs determined by indirect calorimetry or calculated formulas. Based on previous studies [73], the risk of mortality in acute critical illness, including pancreatogenic sepsis, is minimized when 70–80% of the energy requirement measured by indirect calorimetry is provided.

In addition, a large study of the timing of initiation of parenteral nutrition in critically ill patients, including 4640 participants, showed that administration of significant amounts of energy during the first 24 hours in the intensive care unit was associated with an increase in complications. All patients received enteral nutrition. In addition, group 1 received parenteral nutrition from day 1 and group 2 from day 8 in the ICU. The authors found that late initiation of parenteral nutrition was associated with a decrease in infectious complications and ventilator days, and reduced the need for renal replacement therapy [74]. In other studies, patients with increased energy intake were more likely to have episodes of hyperglycemia requiring high doses of insulin [75, 76].

Parenteral nutrition. Despite the benefits of enteral nutrition, approximately 20% of ICU patients require parenteral nutrition, which is currently considered the only form of NS in patients with enteral intolerance, high fistula, and gastrointestinal bleeding [77, 78]. Complications of severe acute pancreatitis may also lead to conditions that preclude enteral NS, such as intestinal obstruction, abdominal hypertension, abdominal compartment syndrome, and intestinal ischemia. Indications for parenteral nutrition may also include enteral intolerance and failure.

Total parenteral nutrition preparations have gained popularity because they combine the advantages of all single-component parenteral nutrition products, containing all necessary substances in one package, and are characterized by high bioavailability, ease of nutrient dosing, and minimal gastrointestinal side effects with intravenous administration.

Omega-3 fatty acids, which are included in a number of parenteral nutrition formulations, have systemic anti-inflammatory effects and may reduce the manifestations of multiple organ failure syndrome and improve clinical outcomes in severe pancreatitis.

A meta-analysis of eight randomized controlled trials showed that parenteral administration of omega-3 fatty acids reduced infectious complications, intensive care unit (ICU) length of stay, and mortality [79, 80].

The administration of parenteral formulas for pancreatic necrosis has unique characteristics. Hypertriglyceridemia is a proven factor in the severity of acute pancreatitis [81]; therefore, lipid emulsions should be administered by infusion pumps and controlled according to changes in the lipid profile. Elevated triglycerides are a limitation for the administration of lipid emulsions, including propofol, which should also be considered during NS [82].

Information on the use of two-component parenteral formulas that do not contain lipid emulsions is limited.

Parenteral vitamins and amino acids (glutamine, etc.) are also used for balanced parenteral nutrition. Four meta-analyses have been published on the use of glutamine in patients with AP. A meta-analysis of ten RCTs involving 433 patients with severe AP showed a significant reduction in infectious complications and mortality in patients receiving glutamine-enriched nutrition [83].

Another meta-analysis of 12 RCTs (505 patients) also showed a significant reduction in infectious complications and mortality after glutamine supplementation in patients with severe AP [79].

Two recent meta-analyses showed the beneficial effects of glutamine administration in patients with AP with increased serum albumin levels, decreased serum C-reactive protein levels, and reduced infectious complications and mortality [80, 84].

Nevertheless, the risk of bias in the studies listed cannot be excluded for many reasons, such as

- small sample size in most of the studies;
- possible heterogeneity of patients with regard to disease severity;
- incomplete analysis of other factors that may influence the outcome.

Macro- and micronutrient requirements. Patients with pancreatogenic sepsis, as in other critical conditions, require sufficient protein, fat, and carbohydrate, as well as micro- and macronutrients, to support homeokinesis of their metabolism [85, 86].

Indirect calorimetry is the «gold standard» not only for calculating the number of calories required, but also for studying the metabolic pathways of essential nutrients, and provides the most accurate real-time assessment of the body's needs.

The limitations of this method force clinicians to calculate proteins, fats, and carbohydrates em-

pirically, and there is no consensus on the amount of essential nutrients required for patients with pancreatic sepsis. Most commonly, 1.2–1.5 g/kg protein/day, 3–6 g/kg/day carbohydrates, and up to 2 g/kg/day lipids are recommended [87].

Previously published clinical guidelines have suggested a significant increase in protein intake in several categories of ICU patients [88]. A detailed analysis of the main sources of these recommendations revealed serious inconsistencies and a lack of an apparent evidence base [89, 90].

Information on the use of vitamins and trace elements in the intensive care of patients with pancreatogenic sepsis is limited.

Refeeding Syndrome. When initiating nutritional and metabolic support, refeeding syndrome should be considered, as it is particularly relevant for surgical patients in the ICU. Refeeding syndrome is a life-threatening condition characterized by metabolic derangements resulting from the resumption of nutrition in patients after prolonged fasting [91, 92]. Any type of nutrition (oral, enteral, or parenteral) can serve as a provoking factor. In addition, the risk of refeeding syndrome in critically ill patients is due more to stress-induced catabolism than to prolonged fasting [93, 94]. Clinical manifestations of refeeding syndrome include acute organ failure (cardiac, hepatic, renal), cerebral and cardiogenic pulmonary edema, thrombocytopenia, DIC, polyneuropathy, and cardiac arrhythmias [95].

To date, the only diagnostic criterion for refeeding syndrome is hypophosphatemia. However, many other conditions can cause low blood phosphate levels in ICU patients, which means that the specificity and prognostic significance of hypophosphatemia in the diagnosis of refeeding syndrome is low [96]. In addition, based on the results of the search for suitable predictors and scales to identify groups of patients at high risk for the syndrome, none of the scales studied showed sufficient specificity and prognostic significance.

Refeeding syndrome is a serious concern for patients with severe AP, and rational NS reduces the risk of its development [97].

Conclusion

Based on the analysis of selected sources, we found that all existing scales for assessing the severity of nutritional deficiency in patients with pancreatogenic sepsis have a low prognostic value, and the mNUTRIC scale is the most appropriate.

The use of parameters to assess the risk of nutritional deficiency according to the ESPEN clinical guidelines is inappropriate for ICU patients.

Indirect calorimetry has been shown to be the preferred method for estimating energy requirements in patients with pancreatogenic sepsis compared to routine calculation formulas.

Such «routine» anthropometric values as body weight, etc. are not always informative and prognostically significant in patients with severe AP in the ICU.

Analgesia, fluid therapy, and diagnosis and management of intra-abdominal hypertension are integral parts of intensive care in patients with pancreatic sepsis and are components of adequate NS.

Early enteral nutrition is the preferred technique for NS, and the choice of tube placement and the mode and rate of nutrient delivery remain controversial. The optimal composition of enteral nutrition for patients with pancreatogenic sepsis has not been specified, which is implicitly confirmed by the variety of enteral formulas available on the market.

We defined the role of refeeding syndrome as a life-threatening condition that develops when NS is initiated.

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