INTRODUCTION

undernutrition is a major public health problem, frequently found in intensive care patients.

Undernutrition results from an imbalance between energy and protein intake and requirements. It is associated with increased mortality rates (1), and morbidity; mainly the occurrence of infections, suture loosening, prolonged length of stay in intensive care and mechanical ventilation.(2,3)

Today in hospital, the cost of undernutrition is much higher than that of obesity. This makes it essential to assess the nutritional status of all intensive care patients from the moment they are admitted, including determining their nutritional risk, needs and protein-energy intake (4). This assessment makes it possible to determine at an early stage the nutritional management strategy best suited to the patient.

According to the European Society for Clinical and Metabolic Nutrition (ESPEN), ICU patients' aggression evolves in three phases: the acute phase, the post-acute phase and the rehabilitation phase, and the objective of nutritional care differs according to these phases (5,6), with the need to introduce nutrition in all ICU patients whose length of stay exceeds 48 hours.

Good nutrition practice will not only improve the nutritional status of patients hospitalized in the ICU, but will also contribute to a better prognosis and effectively reduce mortality and morbidity, which are high in cases of undernutrition.(7)

Our work has the following objectives:

- To define the criteria for diagnosing undernutrition, its incidence in the ICU, and its risk factors.
- Study nutrition in all patients hospitalized in the ICU.
- Comparison of parameters between undernourished and non-denourished patients.
- Define the impact of undernutrition on infection rates, average length of stay and mortality rates in the ICU.

I. TYPE OF STUDY:

This is a retrospective observational study based on the analysis of 180 records from January 1, 2023 to December 31, 2024 on nutrition practices in the intensive care unit P33 surgical emergency resuscitation department of the Ibn Rochd University Hospital in Casablanca.

III. PATIENT SELECTION :

A. Inclusion criteria

All adult patients over 15 years of age admitted to the surgical intensive care unit for more than 48 hours during the study period.

IV. DATA COLLECTION

All patient files admitted to the department during the study period were analyzed, using a pre-established data collection form containing various epidemiological, clinical, biological and nutritional data.

A. Diagnosis of undernutrition

In view of the retrospective nature of our study, we chose the following criteria for undernutrition:

- The notion of weight loss prior to admission.
- The presence of malabsorption/maldigestion.
- The presence of an aggressive situation (acute pathology/evolving chronic pathology/evolving malignant pathology).
- Reduced food intake compared with usual food intake prior to hospitalization.

- Albumin dosage (Table 1).

Table 1: Diagnosis of undernutrition according to albumin

Albumin	Not undernourished	Moderate undernutrition	Severe undernutrition
<70ans	>30	20-29	<20
>70ans	>35	30-34	<30

E. Nutritional data
- Type of nutrition: enteral/parenteral/mixed.
- Approach: peripheral venous route, central venous route, nasogastric/nasojejunal tube, stoma (jejunostomy/gastrostomy).
- Products used: Oliclinomel, Nutrison, preparations, fortimel, trace elements and vitamins.
- Filling solution: saline infusion, glycosylated serum.
- Medication management: antibiotics, insulin, vasopressors, sedation, transfusion of packed red blood cells/albumin/fresh-frozen plasma/platelets.

V. STATISTICAL STUDY

Statistical analysis was carried out in the computer department of the Faculty of Medicine and Pharmacy, Casablanca, using SPSS (Statistical Package for the Social Sciences) V23 software.

Univariate analysis was used to describe the characteristics of our population. Results for qualitative variables are expressed as frequency and percentage, and results for quantitative variables are expressed as mean and standard deviation. The median is used for widely dispersed values.

A two-for KIH test was used to compare percentages of categorical variables.

A p-value of less than 0.05 was considered statistically significant.

RESULTS

I. DESCRIPTIVE STUDY

A. Sample size

Out of 250 files, 180 (72%) were validated.

B. Rates of undernutrition in the ICU

In our sample, 75 patients (42%) were diagnosed as undernourished on admission, while 105 patients (58%) were diagnosed as not undernourished .

C. Description of the general population

1. Epidemiological data

1.1. Age

The mean age of patients was 48 years, with extremes ranging from 15 to 91 years. The predominant age group was between 40 and 65 (42%).

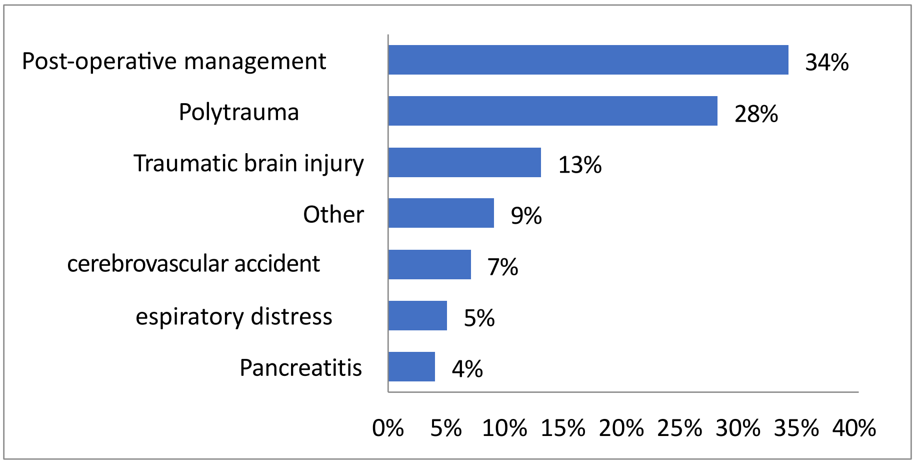
1.2. Gender

There was a predominance of males, 135 (75%) of whom were men and 45 (25%) of whom were women, with an M/F sex ratio of 3.

1.3. Reasons for hospitalization

During the study period, 61 patients (34%) were admitted for post-operative management of digestive surgery. The other reasons are detailed below.

Figure 1: Distribution of patients by reason for hospitalization.



1.4. Length of stay in intensive care

In our study, the average length of stay in intensive care was 14 days, with a standard deviation of 9 days and extremes ranging from 3 to 59 days.

1.5. Risk factors for undernutrition

In our study, the most frequent risk factors for undernutrition were persistent symptoms related to digestive pathology (abdominal pain, vomiting) (18%), age over 65 (17%), diabetes (14%) and cancer (13%).

2. Clinical data

On admission, vital signs were used to assess patient stability (heart rate, blood pressure, use of vasopressors, Glasgow score, respiratory rate and use of intubation).

2.1. Respiratory status on admission

53% Ventilated and sedated vs 47% spontaneous ventilation

2.2 Hemodynamic status on admission

62% stable vs 38% unstable

2.3 Neurological status on admission

The mean Glasgow score was 13, with extremes ranging from 5 to 15 and a standard deviation of 2.

2.4. Temperature

¬ On admission: 149 patients (85%) were apyretic, 11 patients (6%) were febrile, and 15 patients (9%) were hypothermic .

_ Temperature trends: During hospitalization, 96 patients (53%) remained apyretic, while 77 patients (43%) developed hyperthermia and 7 patients (4%) hypothermia .

3. Biological data

3.1. Albumin

141 patients or 78% showed hypoalbuminemia, while 39 patients or 22% had normal levels.

3.2. Total protein

65 patients (87%) were hypoprotidemic, while 10 patients (13%) had normal levels.

3.3 Creatinine levels
103 patients or 57% had normal creatinine levels, while 20% of patients had low levels and 23% had high levels.

3.4. Hemoglobin
100 patients or 56% had anemia, while 70 patients or 39% had normal hemoglobin and 10 patients or 5% had high hemoglobin.

3.5. White blood cells
101 patients (58%) had a normal white blood cell count, while 2% had leukopenia and 40% hyperleukocytosis.

3.6. C-reactive protein (CRP)
In our study, almost all patients presented an inflammatory syndrome with CRP >12 mg/l.

3.7. Procalcitonin
46 patients (75%) had elevated procalcitonin levels.

3.8. Platelets
In our study, 75% of patients had normal platelet levels.

3.9. Venous blood glucose
113 patients or 63% had normal blood glucose levels, 61 patients or 34% had hyperglycemia and 3% had hypoglycemia.

3.10. Electrolytes
The electrolyte balance returned to normal in the majority of patients.

4. Nutritional data

4.1. Approach
In our series, 103 patients or 57% had a parenteral approach (all patients had a central venous line) and 149 patients or 82% had an enteral approach, 95% with SNG and 5% with a stoma.

4.2 Type of nutrition
During hospitalization, all patients were fed. 77 patients (43%) received exclusive enteral nutrition, 31 patients (17%) parenteral nutrition alone, and 72 patients (40%) mixed nutrition.

4.3. Time of introduction of nutrition
For parenteral nutrition, 20% of patients received it on Day 1 and 16% on Day 2. For enteral nutrition, 30% received it on Day 1 and 14% on Day 2.

4.4. Duration of nutrition
The average duration of enteral nutrition was 10 days +/- 9D, with extremes ranging from 1 to 59 days. For parenteral nutrition, the average duration was 5 days +/- 6D, with extremes ranging from 1 to 36 days.

4.5. Products used for nutrition

Table 1: Characteristics of products used for nutrition.

	NUMBER OF CASES	AVERAGE TIME (days)	AVERAGE DOSE /day	Kcal/day
NUTRISON	139	10,35	1L /J	1500
PREPARATION	70	14,81	250 ml /J	-
FORTIMEL	38	12,13	1,2 flacon /J	634
OLICLINOMEL N7	102	8,66	1L /J	732

OLICLINOMEL N4	2	5,78	1L /J	1272

4.6. Vitamin supplementation

In our series, multivitamin dietary supplements (Additiva) were used, while some patients were supplemented with a single type of vitamin (VIT C, VIT B and VIT K).

Table 2: Vitamin supplementation.

	NOMBER OF CASES	AVERAGE DOSE /J
Complexe multivitaminique	120	1 cp/J
VIT C	109	1 cp/J
VIT K	58	1 injection de 10 mg/J
VIT B12	101	1 cp/J

4.7. Micronutrient supplementation

In our series, either a micronutrient complex or exclusive supplementation with iron, selenium or zinc was used.

Table 3: Trace element supplementation.

	NOMBRE DE CAS	DOSE MOYENNE/PATIENT/J
NYTRYELT	3	1 flacon/J
FER	100	1 cp/J
ZINC/SELENIUM	11	1 cp/J

5. Medicines

5.1. Antibiotics

140 patients (78%) received antibiotic therapy, compared with 40 patients (22%) who did not. 18% were on mono-antibiotics, 40% on bi-antibiotics and 42% on tri-antibiotics or more .

1.1 Insulin

137 patients (76%) received no insulin, while 43 patients (24%) received insulin. The distribution according to the dose administered is shown below.

1.1. Vasopressors

In our study, 68 patients (38%) received vasopressors, of whom 40 patients (59%) were on enteral nutrition; noradrenaline was the most commonly used vasoactive drug.

5.4. Transfusion

In our study, 46 patients (26%) received albumin, 89 patients (49%) received packed red blood cells, 20 patients (11%) received platelet packed red blood cells and 15 patients (8%) received fresh frozen plasma. Figure 23 shows the distribution of patients by transfusion type.

5.5. Prokinetics

14 patients (8%) received prokinetics, while 166 patients (92%) did not.

II. CORRELATION STUDY: DENUTRIS / NON-DENUTRIS PATIENTS

A. EPIDEMIOLOGICAL DATA

1. Age

In our study, the over-65 age group was the most affected by undernutrition, with a highly significant correlation p< 0.001.

Undernourished patients had an average age of 59 +/- 16 years, whereas non-undernourished patients had an average age of 40 +/- 17 years.

2. Gender

In our sample, the percentage of undernutrition by gender was higher in women than in men

A correlation between female gender and undernutrition was statistically significant (p=0.004).

3. Reasons for hospitalization

According to the reasons for hospitalization, we found that the reason most at risk of undernutrition is Postoperative management of digestive surgery, with a highly significant correlation p< 0.01.

4. Length of stay in intensive care

The average length of stay for malnourished patients was 15 days+/- 9J. For patients without malnutrition, the average length of stay was 13 days +/- 8 days.

No significant correlation between length of stay and malnutrition.

B. Clinical data

1. Type of ventilation

In our series, 47% of malnourished patients were ventilated/sedated, compared with 58% of non-malnourished patients . We found no correlation between malnutrition and ventilation/sedation.

2. Temperature

In our series, we found no correlation between temperature and undernutrition.

C. Biological data

1. White blood cells

In our series, 78% of patients without malnutrition had a normal white blood cell count, compared with 25% of those with malnutrition

The correlation between malnutrition and white blood cells was statically significant p< 0.001.

2. C-reactive protein (CRP)

In our sample, 58% of non-undernourished patients showed elevated levels, compared with 42% of undernourished patients. There was no significant correlation with undernutrition.

3. Haemoglobin

In our sample, 76% of malnourished patients had anaemia compared with 51% of non-malnourished patients

A significant correlation was observed with malnutrition p= 0.002.

4. Creatinine levels

In our sample, 37% of malnourished patients had low creatinine levels, compared with 8% of non-malnourished patients

We found a significant correlation with malnutrition p = 0.002.

5. Platelets

In our study, 40% of malnourished patients had thrombocytopenia compared with 14% of non-malnourished patients, with a significant correlation p<0.001.

6. Venous glycemia

We found that the malnourished population presented more glycemic disturbances than the non-malnourished population.

The correlation was highly significant (p=0.001).

7. Electrolytes

In our series, 51% of malnourished patients presented hydroelectrolytic disorders compared with 15% of non-malnourished patients

There was a significant correlation with malnutrition p< 0.001

D. DRUG MANAGEMENT & UNDERNUTRITION

1. Antibiotic therapy

We found that 59% of patients who received antibiotic therapy were not undernourished, compared with 41% of undernourished patients

No significant correlation between undernutrition and antibiotic use.

2. Insulin therapy

In our study, 54% of patients who received insulin therapy were undernourished compared with 46% of patients who were not.

No significant correlation between undernutrition and insulin consumption.

3. Red blood cell transfusion

In our sample, we found a significant correlation between undernutrition and red blood cell transfusion p= 0.017.

4. Albumin transfusion

In our series, 87% of patients transfused with albumin were undernourished, compared with 13% of non-undernourished patients

There was a statically significant correlation between albumin transfusion and undernutrition p< 0.001.

E. Nutrition-related complications

1. Digestive complications

In our series, 40 patients (22%) developed digestive complications, including :

- 17 patients (9%) presented with diarrhea,
- 13 patients (7%) presented with vomiting
- 10 patients (6%) experienced constipation.

There was no significant correlation between these digestive complications and enteral nutrition.

2. Hyperglycemia

Of the 61 patients who presented with hyperglycemia, 41 patients or 67% were on parenteral nutrition alone or mixed, compared with 20 patients or 33% on enteral nutrition, 24 of whom were diabetic.

The correlation between parenteral nutrition and hyperglycemia was significant (p=0.04).

F. Nosocomial infections & undernutrition

97 patients (54%) developed a nosocomial infection, while 83 patients (46%) did not.

In our sample, we found a significant correlation between the occurrence of nosocomial infection and undernutrition p < 0.001

G. Mortality & undernutrition

All pathologies combined, the prevalence of overall mortality reached 56% , with a mortality rate of 76% for patients diagnosed as undernourished on admission and 40% for those who were not.

The correlation between mortality and undernutrition was statistically significant (p<0.001).

Table 4: Summary table.

	Undernourished patients	Non-denourished patients
Age	59 ans +/- 16J	40 ans +/- 17J
Gender	W (60%) M (36%)	W (40%) M (64%)
Reason for hospitalization	Postoperative management of digestive surgery	Polytrauma Traumatic brain injury
Length of stay	15 jours +/- 9J	13 jours +/- 8J
Intubated / Ventilated	47% (NS)	58%
Nosocomial infection	71% (p=0,001)	42%
Mortality	76% (p<0,001)	40%

DISCUSSION

I. DENUTRITION

A. Definition and pathophysiology:

Undernutrition is a condition in which the body is nutritionally unbalanced.

An imbalance between the body's protein-energy intake and requirements leads to involuntary tissue loss, with deleterious functional consequences for the body and a worsening of disease prognosis.(8)

There are 2 main forms of undernutrition, each at the end of the same pathophysiological continuum, and the 2 forms may coexist.

1. Intake-deficiency undernutrition =Exogenous undernutrition

This is mainly reflected in anthropometric terms (weight loss and/or low BMI), and is accompanied by improved metabolic adaptation to insufficient energy and protein intake, through stimulation of lipolysis-related ketogenesis and reduced recourse to gluconeogenesis, while preserving protein capital.(9)

Situations characterized essentially by reduced intake (known as anorexia) are :

Chronic pathologies such as algic, depressive, maldigestion or malabsorption syndromes, cirrhosis, alcoholism, AIDS, bronchopneumopathy, renal failure..

Heavy therapeutic consequences such as chemotherapy, radiotherapy or surgery.

The elderly / polymedication...

2. Hypermetabolic undernutrition = endogenous undernutrition

Even if there is a certain heterogeneity in patients staying in intensive care (polytrauma/ sepsis/ burns/ cancer/ organ failure: cardiac or respiratory failure...), there is a common metabolic picture linked to severe aggression. This is responsible for a systemic inflammatory response syndrome (SIRS).(10)

In situations of severe aggression, a deterioration in protein reserves with muscle wasting is observed, leading to a negative nitrogen balance resulting from an imbalance between increased proteolysis and decreased protein synthesis. (11)

This hypercatabolic state is activated by the secretion of pro-inflammatory cytokines (mainly TNF, IL-1, IL-6) and so-called counter-regulatory hormones (cortisol, glucagon, catecholamines), the latter contributing to insulin resistance, which in turn activates gluconeogenesis from circulating amino acids(12).

B. Risk factors for undernutrition:

These are essentially risk factors related to the patient and/or associated therapies.

1. patient-related risk factors:

Age

Undernutrition is common after the age of 60. Its prevalence varies between 2% and 4% in subjects aged between 60 and 80 living at home. Over the age of 80, the prevalence exceeds 10%.

The main mechanism of undernutrition in the elderly is a deficit in protein-energy intake, for a variety of reasons: changes in taste and dentition, loneliness, depression, overuse of medication and diets, and numerous fears and taboos.

Age over 70 is often considered the most relevant factor in predicting undernutrition(13,14)

Cancer

Cancer is often associated with undernutrition. The prevalence of undernutrition depends on the location and stage of the cancer in question. It is around 60% in ENT and upper digestive tract cancers (esophagus, stomach and pancreas). Prevalence in breast, prostate and colorectal cancers varies from 12 to 30%, and is much higher in metastatic cancers(15,16).

Finally, between 1/5 and 1/2 of patients with haematological malignancies are malnourished. Prevalence varies according to the type and stage of haemopathy.(17)

Chronic diseases

All chronic diseases, particularly organ failure (respiratory, cardiac, renal, intestinal, pancreatic, hepatic), are associated with a risk of undernutrition. Their progression is accompanied by an increase in resting energy expenditure (REE) and a reduction in oral protein-energy intake. This is also the case for diabetic patients, patients with chronic digestive pathologies, or patients undergoing treatment for inflammatory syndromes.(18)

Patients infected with the human immunodeficiency virus (HIV) are also at particularly high risk of undernutrition.(19)

Finally, in almost half of all cases, depression is complicated by reduced food intake and undernutrition.

Persistent symptoms

The presence of digestive symptoms (anorexia, nausea, vomiting, diarrhea, abdominal pain, dysphagia) lasting more than 15 days is associated with a high risk of undernutrition.(20)

Similarly, the presence of chronic dyspnea secondary to chronic obstructive pulmonary disease (COPD) or chronic obstructive pulmonary insufficiency (COPF) is associated with a high risk of undernutrition is responsible for a reduction in food intake, leading to undernutrition(21).

2. Treatment-related risk factors:

Anti-cancer treatments (radiotherapy and chemotherapy)

Radiotherapy and chemotherapy have a major nutritional impact. They are carried out on patients who are usually malnourished as a result of their cancer.(16,22)

Malnutrition is present in 90% of patients receiving cervical or mediastinal irradiation for cancers of the ENT sphere, oesophagus or bronchial cancers.(23,24)

Radiation-induced stomatitis or oesophagitis, changes in taste and saliva production are the main causes of reduced food intake.(23)

Combined radio-chemotherapy induces malnutrition in half of patients.

Nevertheless, the complications and side-effects of chemotherapy, such as stomatitis, esophagitis, nausea and vomiting, dysgeusia or diarrhea, are associated with reduced food intake, and therefore a high risk of undernutrition(25).

Oral corticosteroids

It is well established that systemic corticosteroids induce protein hypercatabolism, leading to muscle wasting. Corticosteroids can affect muscle protein metabolism in several ways. They activate certain proteolysis pathways and inhibit protein synthesis by limiting ribosomal activity and inhibiting the synthesis of anabolic proteins such as IGF1 (insulin-like growth factor-1) and growth hormone (GH).(26)

Long-term corticosteroid therapy is thus responsible for chronic myopathy, characterized by a reduction in muscle mass, strength and endurance. It is associated with a risk of undernutrition.(26,27)

Polymedication

Polymedication is defined as taking more than five drugs a day. Over-medication increases the risk of protein-energy deficiency, particularly in the elderly.(28)

At the same time, some drugs, such as antidepressants, are anorectic.

C. Consequences and complications of malnutrition

Malnutrition is accompanied by its own complications. Severe malnutrition, with depletion of lipid and protein reserves in muscle and organs, is life-threatening.

All tissues undergoing rapid protein renewal are affected by a shortage of synthetic materials, particularly in:(29)

- Exocrine pancreas: -Secretory insufficiency
- Bone marrow: -Anemia / Leukopenia
- Small intestine: - Partial villous atrophy
- Functional abnormalities of intestinal epithelium
- Risk of microbial pullulation favored by relative immunoglobulin deficiency

Immunocompetence is compromised, resulting in an increase in the frequency and severity of infections, which in turn increase undernutrition, leading to a veritable vicious circle (Figure 45), as well as a predisposition to artificial ventilation in the event of respiratory illness, and delayed weaning.(30,31)

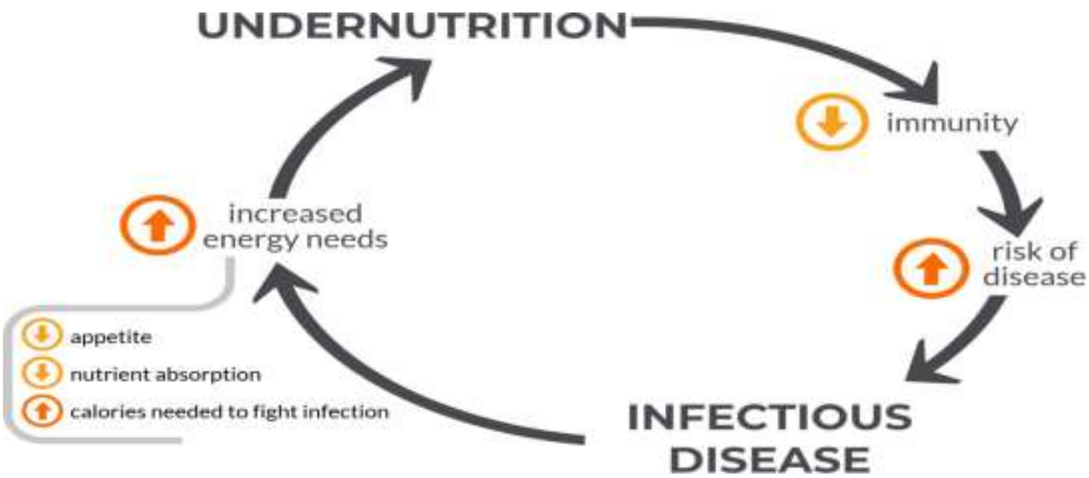
Protein-energy substrates and micronutrients are essential for wound healing. Undernutrition is the cause of delayed wound healing. This delay affects both dermal healing processes and bone repair.(32)

Malnutrition alters collagen synthesis, immune function, and oxygen supply to tissues (by impairing red blood cell production and cardiovascular and respiratory function). These changes are responsible for delayed healing(33).

Skeletal muscle damage is responsible for reduced muscle strength and fatigability, leading to physical asthenia and, later, immobilization complicated by pressure sores. (34,35)

Responses to aggression and heavy therapy are inadequate, which explains the increase in morbidity and mortality among undernourished patients hospitalized in intensive care units.(36)

Undernutrition is correlated with a poor survival prognosis in patients with chronic pathologies, such as chronic respiratory failure and chronic renal failure.(37,38)



II. ASSESSMENT OF NUTRITIONAL STATUS / DIAGNOSIS OF UNDERNUTRITION

A. EVALUATION OF NUTRITION

Because of the serious consequences of undernutrition: reduced functional capacity, increased morbidity, delayed wound healing, increased secondary infections and, above all, mortality, the ultimate consequence of undernutrition. Assessing and monitoring nutritional status is playing an increasingly important role in the management of undernourished patients.

However, as no single parameter is highly specific in assessing nutritional status, many different tools are used. These are anthropometric and biological, and composite indices are available to increase the sensitivity of these markers(39).

1. Anthropometric data

1.1. Weight/height:

The main clinical warning sign is weight loss.

Measurements of weight and height should be taken in underclothing, if possible in the morning on an empty stomach, using a method appropriate to the patient's degree of autonomy: bathroom scale, chair scale or weighing system coupled to a patient lift(40).

In patients who cannot be placed in an orthostatic position, or in whom height measurement may be distorted (kyphosis, scoliosis, vertebral compression), heel-knee height measurement can be estimated with the aid of a specific equation.(8)

Chumlea formulas:

- Male height (cm) = (2.02 x dTG cm) - (0.04 x age years) + 64.19
- Female height (cm) = (1.83 x dTG cm) - (0.24 x age years) + 84.88

Percentage weight loss is calculated using the formula:(41) [Usual weight - current weight)/Usual weight x 100]

This is the simplest criterion for undernutrition. Weight loss of more than 10% is predictive of postoperative complications in major surgery (nosocomial infections/suture loosening)(42,43).

1.2 Body Mass Index (BMI)

Body Mass Index (BMI) is the ratio of weight (kg) to height squared (m) = P/T2, and is used to specify the level of corpulence and quantify the level of thinness.

BMI is normally between 18.5 and 25. Undernutrition is defined as BMI < 18.5 kg/m2 (44).

The Club francophone gériatrie et nutrition used a BMI threshold of 21 to define undernutrition in people over 70(45).

1.3 Lean mass/muscular strength

In the presence of oedematous syndrome, calculations of weight loss and BMI are flawed. In this situation, measurement of brachial circumference has been shown to provide a good assessment of nutritional status, as arm circumference correlates well with BMI.(46)

Normal values are: 20-30cm (women) and 25-27cm (men).

Estimated muscle strength can also be used to assess nutritional status and its evolution, using a manual dynamometer(47).

2. Biological data

The interpretation of a nutritional protein balance, transthyretinemia or albuminemia, must take into account the existence of interfering factors, notably excessive losses from the digestive tract (malabsorption), kidney (nephrotic syndrome), skin (severe burns) and inflammation, which lead to a reduction in plasma protein concentrations. (48)

In practice, it is essential to measure CRP in parallel with albumin and transthyretin, in order to be able to interpret variations in the latter.

2.1. Albumin

Albumin accounts for 55% to 65% of circulating proteins. It plays a major role in maintaining oncotic pressure, and is involved in the transport of many endogenous ligands.

Its normal serum concentration is between 35 and 45 g/l, with a half-life of 20 days. Inflammatory syndromes, hepatocellular insufficiency and glomerular or digestive leakage can lead to hypoalbuminemia. In isolation, albumin levels are unsuitable for monitoring rapidly fluctuating situations, but remain the benchmark for long-term evolution.

Albuminemia reflects the risk of undernutrition-related complications. The risk of undernutrition-related complications is moderate when albuminemia is between 30 and 35 g/L, and severe when it is below 30 g/L.(49)

However, numerous studies demonstrate the increased morbidity and mortality in patients with hypoalbuminemia.(50)

2.2. Transthyretin (TTR)

Transthyretin, previously known as prealbumin, is responsible for transporting retinol and thyroid hormones. It has a short half-life of 2 days, and its normal serum concentration is between 250 and 350 mg/l, with significant physiological variations linked to sex and age(51).

It is a sensitive marker of protein-energy malnutrition, but is nonetheless not very specific, and its concentration falls in liver failure and inflammatory syndromes(52). It can be used to identify rapid fluctuations in nutritional status(53). Like albumin, a low concentration is associated with excess morbidity(54). Undernutrition is said to be moderate if transthyretin is below 160 mg/l, severe if below 107 mg/l(55).

2.3 Transferrin

Transferrin is a protein with an intermediate half-life of 8 days, and a usual value of 2 to 4 g/L. In the absence of protein-energy malnutrition, martial deficiency will stimulate hepatic transferrin synthesis to spare residual iron stores and facilitate metabolic utilization. In this case, transferrin concentrations rise. In undernourished patients, however, transferrin levels may fall if the workup does not reveal iron deficiency. If iron deficiency does exist, the variation in transferrinemia can no longer be interpreted in the undernutrition work-up(56).

2.4. Markers of the inflammatory response

Inflammation induces a decrease in hepatic synthesis of nutritional proteins in order to increase the bioavailability of amino acids for the synthesis of inflammatory response proteins. For this reason, assessment of the inflammatory state is inseparable from biological exploration of the nutritional state.(57)

An inflammatory state is biologically objectified by an increase in CRP (half-life 19 h, usual value < 5 mg/l), defining an acute inflammatory syndrome, or in orosomucoid (half-life 72 h, usual values 0.5 to 1.2 g/l) for the exploration of a chronic inflammatory syndrome.

Hematology results can also be consulted. The most relevant parameters are increased fibrinogen and neutrophil concentrations.

2.5. Creatininemia/Creatinine index

The assessment of muscle mass has also been one of the mainstays of nutritional assessment.

In addition to its vital role in assessing renal function, creatinine is also useful in assessing muscle mass, decreasing in parallel with the degree of amyotrophy.

The creatinine index (creatininuria/height) may reflect muscle mass. One kilogram of muscle corresponds to 23 mg of creatinine eliminated daily in men and 18 mg in women. This index is unusable in cases of renal failure and rhabdomyolysis(58,59).

2.6. Nitrogen balance

Nitrogen balance is used to monitor the effectiveness of nutritional management and to adapt nitrogen intake to the needs of a given patient. The nitrogen balance represents the difference between ingesta and excreta; a positive nitrogen balance reflects an anabolic state, a negative nitrogen balance reflects a catabolic state(60).

2.7. multiparametric indexes

The aim of these indexes is to identify patients at risk of undernutrition-related complications, particularly infectious ones.

- Buzby Nutritional Risk Index (NRI)

This index takes into account variations in weight and albumin levels.

The NRI is defined by the following equation:(61)

NRI = 1.519x albuminemia (g/l) + 41.7 x (current weight/usual weight).

The results enable us to classify patients into 4 categories according to their risk of morbimortality:

- NRI > 100 no risk
- 97.5 《 NRI 《100 low risk
- 83.5 《NRI 《97.5 moderate risk
- NRI <83.5 major risk

To this end, the Buzby index must be integrated into a strategy for screening for and managing undernutrition.(62)

- Nutritional and inflammatory prognostic index (PINI)

This combines the determination of two inflammation proteins, CRP and orosomucoid (Oroso), and two nutrition proteins, albumin and TTR.

PINI = [CRP (mg/L) x Oroso (g/L)] / [Alb (g/L) x TTR (g/L)

PINI is normally close to 1, and correlates well with the clinical course of patients:

- 1 to 10 Low risk of complication
- 11 to 20 Moderate risk of complication
- 21 to 30 High risk of complication

- > 30 Life-threatening

These threshold values apply to chronically malnourished patients, children, adults and the elderly. Much higher threshold values have been defined for patients suffering from aggression(63). This is not a nutritional index, but an index of the risk of morbidity and mortality associated with undernutrition. Several studies have found an association between a high PINI value and increased short-term mortality(64).

B. Diagnosis of undernutrition

1. Diagnosis of undernutrition in adults (≥18 years and<70 years)

The diagnosis of undernutrition requires the presence of at least: 1 phenotypic criterion and 1 etiological criterion.(49)

Phenotypic criteria: 1 single criterion is sufficient

- BMI <18.5kg/m2
- Quantified reduction in muscle mass and/or function
- Weight loss ≥ 5% in 1month or ≥ 10% in 6months or loss ≥ 10% compared with usual weight before disease onset.

Etiological criteria: only 1 criterion is required

- Reduced absorption (maldigestion/malabsorption)
- Aggressive situation: acute pathology
- Evolving malignant pathology or
- Evolving chronic pathology.
- Reduction in food intake ≥ 50% for more than a week, or any reduction in intake for more than 2 weeks compared:

usual food intake or protein-energy requirements.

When the diagnosis of undernutrition is established, and only when it is established, it is recommended to determine its degree of severity.

Moderate: (1 single criterion is sufficient):

- 17 < IMC < 18.5KG/M2
- 30g/L < albumin < 35g/l
- Weight loss ≥ 5% in 1month or ≥ 10% in 6months or compared with usual weight.

Severe :(1seul critère suffit) :

- BMI ≤ 17kg/m2
- Albumin ≤ 30g/l
- Weight loss ≥ 10% in 1month or ≥ 15% in 6months or relative to usual weight.

When a single criterion of severe undernutrition and one or more criteria of moderate undernutrition are observed simultaneously, undernutrition is qualified as severe.

2. Diagnosis of undernutrition in the elderly (≥ 70 years)

The diagnosis of undernutrition is based on the presence of one or more of the following criteria (49):

- Weight loss: ≥ 5% in 1 month, or 10% in 6 months
- BMI < 21
- Albuminemia < 35 g/l
- Global MNA < 17

Severe undernutrition is defined by the presence of one or more of the criteria below:

- Weight loss: ≥ 10% in 1 month, or 15% in 6 months
- BMI < 18
- Albuminemia < 30 g/l

III. NUTRITIONAL ASSISTANCE IN INTENSIVE CARE

A. Nutritional intake

Accurate estimation of energy requirements and assessment of the energy target in intensive care are based on indirect calorimetry; when the latter is not available or not feasible, predictive formulas can be used, despite their lack of precision.(65,66)

Among these is the Harris and Benedict equation weighted by correction factors.

- MB (Male) = 66.47 + (13.75 x P) + (5.00 x T) - (6.75 x A)
- MB (Female) = 655.10 + (9.56 x P) + (1.85 x T) - (4.68 x A)

MB: Basal Metabolism, P: Weight in Kg,
T: Height in cm,
A: Age in years.

Correction factors are (MB x factor =energy expenditure):

- Post-operative period =1 to 1.1
- Severe fractures =1.1 to 1.3
- Severe infection =1.3 to 1.6
- Burns =1.5 to 2.1

The use of these formulas depends on the presence or absence of undernutrition. In the absence of undernutrition, total caloric intake should be 20-25 kcal/kg current weight per day in the acute phase of the attack, then 25-30 kcal/kg current weight per day in the post-acute phase. In cases of severe undernutrition and/or prolonged fasting lasting more than a week, artificial nutrition should probably be started with an energy intake of 10 kcal/kg per day, then gradually increased according to the patient's tolerance, up to a maximum of 25-30 kcal/kg current weight per day. In obese or overweight patients, energy requirements could be estimated at 15 kcal/kg current weight per day or 20 kcal/kg adjusted weight per day. Adjusted weight is calculated according to the formula :

ideal weight+0.33(current weight- ideal weight)(67)

1. Macronutrient and micronutrient requirements

Recommended caloric intake should be ensured by a combination of carbohydrates, providing 50-70% of total energy requirements. Persistent hyperglycemia above 10mmol/L has been blamed for an increased risk of nosocomial infection, and insulin therapy is required to maintain blood sugar levels within subnormal limits. Protein intake should be between 15 and 20%, with a daily protein intake of between 1.3 and 1.5 g/kg/d. Lipid intake (15 to 30%) should include essential fatty acids. An intake of omega-3 fatty acids, capable of generating the synthesis of eicosanoids with anti-inflammatory potential, unlike those derived from the omega-6 fatty acid series, is proposed to modulate inflammation.(68)

Certain vitamins, notably B12, C, D and K, and trace elements such as iron, zinc and selenium, are specifically involved in multiple biological mechanisms to combat oxygenated free radicals. In the intensive care patient, these micronutrients may be in short supply, due to previous depletion as a result of deficiency, acute increase in losses (capillary or digestive leakage) or increased requirements as a result of inflammatory processes.(69)

Phosphorus requirements can be up to ten times higher than normal in patients in respiratory distress and when glucose intake is high, as well as during renutrition syndromes (70). Some consider that iron deficiency is an adaptive defensive response to infection or trauma, and that attempts to correct it could facilitate its availability to microorganisms. For other authors, iron deficiency impairs resistance to infection and should be corrected if very high (71).

Zinc deficiency may be responsible for the persistence, and even the onset, of septic states due to immune deficiency (72). Zinc requirements can reach 20-30 mg/d when protein intake is not from natural proteins (enteral nutrition), but from crystalline amino acid solutions (parenteral nutrition). Circulating selenium concentrations drop rapidly in severe infectious states. A minimum daily intake of approx 200 µg may be required to normalize serum concentration and selenium-dependent enzyme activity.(73)

Basic daily micronutrient requirements should therefore be met. Patients undergoing extra-renal purification should be given increased intakes of water-soluble vitamins and trace elements, as their losses are significantly increased(68,74).

2. Immunonutrition

The term immunonutrition is used to describe specific solutions enriched with a number of nutrients designed to modulate the immune system.

These solutions combine immunonutrients with specific effects: arginine stimulates the immune response, thus promoting resistance to infection and healing processes; omega-3 fatty acids limit the exacerbation of the inflammatory response; nucleotides stimulate cell proliferation, particularly intestinal and immune cells. (6)

Preoperative administration of a pharmaconutrition comprising arginine, omega-3 fatty acids and nucleotides helps to limit postoperative complications after digestive carcinological surgery. When the patient requires artificial nutrition in the postoperative period, this administration should be continued(75,76).

On the other hand, the administration of arginine-enriched mixtures in septic patients increases the risk of complications, prolongs length of stay and, in some studies, increases mortality(77).

In severely malnourished cancer patients who have not benefited from preoperative enteral nutrition, parenteral nutrition supplemented with glutamine may be considered(78). Glutamine supplementation is associated with shorter hospital stays and lower costs than standard parenteral nutrition(79). It also boosts the immune system, stimulating the production of anti-inflammatory cytokines and reducing that of pro-inflammatory cytokines, stimulating protein synthesis, strengthening the mucosal barrier and protecting intracellular glutathione content (80- 81-82).

B. How nutrition is administered

There are 2 types of artificial nutrition: parenteral nutrition, administered via the venous route, and enteral nutrition, administered directly into the digestive tract, via a nasogastric tube or gastrostomy/jejunostomy.(80)

The enteral route is preferred wherever possible, and should be preferred to parenteral nutrition in the absence of contraindications.

1. Enteral nutrition

Enteral nutrition should be started within the first 24 hours in patients who are malnourished or judged unable to eat sufficiently within three days of admission.(67)

This early initiation must be balanced, bearing in mind that nutritional assistance is not a priority in hemodynamically unstable patients with the risk of developing intestinal ischemia. (81,82)

In stable patients at low nutritional risk, whose length of stay in the intensive care unit should not exceed a few days, enteral feeding offers little benefit, and maintenance of oral nutrition, even if reduced, should be preferred(83).

1.1 Indications

The advantages of enteral nutrition over parenteral nutrition:

- Is more physiological ;
- Prevents atrophy of the digestive mucosa, intestinal bacterial translocation and maintains digestive functions;(84)
- Less complication ;
- Integrates all nutrients (macro and micronutrients) in a single solution;
- is less expensive.

1.2 Contraindications

- Intestinal obstruction ;
- Active digestive hemorrhage;
- High-flow digestive fistula;
- Intestinal ischemia;
- Uncontrolled shock(85).

1.3 Mixtures

Standard solutions

- Are polymeric: contain nitrogen in the form of proteins or long polypeptides, lipids in the form of long-chain triglycerides and carbohydrates, usually in the form of partially hydrolyzed starch;
- Normo caloric (1 kcal/ml), hypocaloric (< 1 kcal/ml) or hypercaloric (>1 kcal/ml) and/or hyperproteinic (> 19% nitrogen intake). All these mixes contain electrolytes, vitamins and trace elements(86).
- Contain fiber (soluble and insoluble) to improve digestive tolerance.(87)

Specific solutions

- Are semi-elemental: contain nitrogen in the form of partially hydrolyzed proteins and, more often than not, lipids in the form of medium-chain triglycerides.
- In the case of malabsorption syndrome, short-grain syndrome or acute pancreatitis, nutrient absorption capacity is limited. The use of a semi-elemental blend can ensure better absorption(88).

1.4. Administration equipment and techniques

- Nasogastric or nasojejunal microprobes are the most frequently used.(89)
- The use of small-calibre silicone or polyurethane probes improves tolerance.
- Gastrostomy tubes should be considered for any foreseeable duration of enteral nutrition exceeding 1 month. (90)

They provide greater physical and psychological comfort.

However, they do not prevent gastro-oesophageal reflux.

There are three types of insertion:(91)

- Endoscopic
- Radiological
- Surgical
- In some cases, when gastrostomy is not possible, a jejunostomy tube is used(92).
- The volume administered should be increased progressively, using a pump and continuously, 24 hours

a day, to avoid bloating and intestinal problems.(93,94)

While avoiding the strict supine position (risk of regurgitation), the patient should be placed in a 1/2 seated position (at least 30° inclination) in the absence of contraindications (spinal trauma, hemodynamic instability).(95,96)

1.5. Complications

Inappropriate renutrition syndrome (IRS):

Can occur with both enteral and parenteral nutrition. It is defined by the set of deleterious biological and clinical manifestations that occur during the renutrition of undernourished patients or those who have undergone prolonged malnutrition. Overly rapid, poorly managed renutrition can lead to hypophosphatemia, hypomagnesemia, hypokalemia, hyperglycemia, hypovitaminosis B1, hydrosodium overload and the collapse of various organ functions, in particular cardiac, neurological, respiratory, renal, hepatic, muscular and hematological. Death may occur in the context of multivisceral failure syndrome(97). The serious consequences of IBS mean that it must be prevented by the gradual introduction of intakes, while monitoring

daily monitoring of phosphatemia, magnesemia and kalemia, particularly during the first 72 hours of the intensive care unit stay, whatever the route of administration(98).

Transit disorders: Diarrhea / Constipation

Several factors are incriminated in the appearance of these disorders: tube position, type of feeding, too rapid flow rate, bacterial contamination of solutions, use of antibiotics or transit gas pedals, prolonged bed rest, fiber-free solutions, insufficient hydration, excessive use of sedation and morphine derivatives.... (99,100)

Nausea/vomiting/inhalation pneumonia:

Favored by too rapid administration, slow gastric emptying, poor tube positioning, strict prone position, displaced tube. (101,102)

The administration of prokinetics (metoclopramide and/or erythromycin) can improve overall caloric intake in the event of disturbed gastric emptying (103,104), but if these disturbances persist, the post-pyloric site may be considered.(105,106)

¬ Clogged catheter:

Promoted by the use of insoluble drugs, inadequate rinsing, excessive solution viscosity.(107)

2. Parenteral nutrition

2.1 Indications

When available, enteral nutrition should always be preferred.(108)

Parenteral nutrition is an alternative in cases of contraindication, failure of well-managed enteral nutrition and/or if oral or enteral intake is below 50% of theoretical requirements, for at least 5 to 7 consecutive days. (109,110)

The systematic use of parenteral nutrition during the first 48 hours after admission is not recommended, as it increases morbidity.(111)

The reasonable attitude would be to start parenteral nutrition at 7 days. This is in line with the fact that it seems preferable to limit rather than completely correct early energy deficits. Excessive over- or under-compensation of energy requirements increases the risk of complications(112).

2.2 Mixtures

- As a general rule, preference is given to ready-to-use solutions known as (ternary) because they contain a mixture of the 3 types of macronutrients (proteins, lipids and carbohydrates).(113)

- If lipid-containing ternary solutions are contraindicated, so-called (binary) solutions composed of amino acids and carbohydrates can be used.
- These are administered either alone, or with the required lipids administered simultaneously(87).
- In the case of exclusive parenteral nutrition, macronutrient metabolism is impossible in the absence of vitamins and trace elements. They must therefore be supplemented in the bag or by means of a Y infusion.(112,114)

2.3 Administration equipment and techniques

- Parenteral nutrition should be administered continuously using a flow-controlled electric nutrition pump, avoiding cyclic administration in order to limit significant variations in blood glucose and triglyceridemia.
- Because of their high osmolarity >850mOsm/l, most solutions must be administered via a central venous line. This route, dedicated to the administration of parenteral nutrition, cannot be used for drug injection or transfusion. (86), only parenteral nutrition solutions with low osmolarity <850mOm/l can be administered by the peripheral route.(115)

2.4. Complications

Inappropriate renutrition syndrome.(116)

Metabolic disorders:

Hyperglycemia, hypertri-glyceridemia, dysnatremia and hepatopathy, including hepatic steatosis, can occur with parenteral nutrition, regardless of the duration of nutritional support.

- Preventing hyperglycemia is an important aspect of nutritional management in the ICU, as hyperglycemia is associated with increased morbidity and mortality. The aim of glycemic control is to keep blood glucose levels below 10 mmol/l.(117)
- Optimization of glycemic control is based on the preferential use of enteral nutrition, which is associated with a reduced risk of hyperglycemia and lower insulin requirements than parenteral nutrition(118,119).
- Lipid intake should be less than 1.5g/kg/day, in order to reduce the risk of hepatic steatosis occurring with prolonged parenteral nutrition(112).

Catheter infection:

Remains a frequent and serious complication of parenteral nutrition, making it essential to observe aseptic practices when handling catheters and administering solutions.(120)

Venous thrombosis:

Central catheter-related is a potentially serious and probably underestimated complication. Low-dose oral anticoagulants may reduce the risk of central venous thrombosis in patients on prolonged parenteral nutrition.(121)

LIMITS AND RECOMMENDATIONS

A. LIMITATIONS

- Retrospective nature of the study.
- Lack of anthropometric (weight/height) and biological (transthyretin) data on admission.
- Lack of clinical monitoring of the nutritional status of patients on artificial nutrition.
- Heterogeneity of the study population:
- Polytrauma

- Head trauma
- Post-operative follow-up
- Medical pathologies.

B. RECOMMENDATIONS

- Evaluate and monitor the nutritional status of all patients entering intensive care by measuring weight (bed with weighing system) and height, and measuring transthyretin.
- Carry out a comparable prospective study on a large sample over a long period.
- Ensure early nutritional management of malnourished patients.
- Consider training sessions on nutritional concepts to help improve prognosis and reduce mortality and morbidity.
- Systematic collaboration between the entire medical team - resuscitators, nurses and dieticians - is essential to ensure that patients are in an adequate nutritional state.

CONCLUSION

The impact of undernutrition on morbidity and mortality is a proven cause for concern. Its prevalence is probably underestimated.

Assessment of nutritional status should be a routine part of the clinical examination on admission.

In our study, although it was difficult to assess nutritional status due to a lack of clinical (weight/height) and biological (transferrin) data, the incidence of undernutrition was 42%, although this varies considerably between authors due to the different means used to diagnose protein-energy undernutrition.

Our study showed a high mortality rate among undernourished patients (76%). Nosocomial infection, hydroelectrolytic disorders and hyperglycemia were identified as predictive factors for the severity of undernutrition.

All patients hospitalized in the ICU require early and appropriate nutritional management, in order to maintain an adequate nutritional status.

Nutritional management in the ICU is an important issue for medical teams, and is now an integral part of patient care, with the need to involve dieticians with medical staff in the ICU, and to make available the elements required for optimal nutritional management.

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