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MASTER THESIS

Victoria Oline Ringseth

Nutrition in the intensive care patient

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Department of Clinical Medicine, Center for Nutrition

Thesis supervisor: Assistant professor Randi Julie Tangvik

Co-supervisor: Professor Anne Berit Guttormsen

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Abstract

Introduction

Nutritional therapy in critically ill patients requires recurring assessments to accommodate the increased nutritional demands alongside the decreased tolerance for receiving nutrition in the stress-induced hypermetabolic state. This project aimed to investigate the nutritional status of patients admitted to the intensive care unit at Haukeland University Hospital (HUH) and how this changed during stay. Secondary aims were to estimate nutritional requirements, map the nutritional therapy and to evaluate the compliance to the local nutritional protocol (LNP).

Method

Data collection for this observational study was done between August 2022 and October 2022 on the intensive care unit at HUH. Information on nutritional status was retrieved from patient journals and charts including body weight, height, and body mass index (BMI). Measurements of mid-upper arm circumference (MUAC) and a bioimpedance analysis (BIA) of body composition were performed by the master student. BIA-parameters of interest were phase angle (PhA) and body cell mass (BCM). These were measured at baseline and compared to new measurements done at discharge. Also, the master student assessed patients for nutritional risk using the Nutrition Risk in the Critically Ill (NUTRIC)-score. Nutritional requirements were estimated by the master student based on the weight and height measurements registered at admission in patients records. The nutritional calculator that has been implemented in the unit was used to estimate nutritional requirements. Requirements were based on 20-30 kcal/kg and 1.3 grams protein/kg body weight per 24 hours, respectively. Information on nutritional therapy was retrieved from patient charts and records. This included registered daily energy and protein intake, non-nutritional energy sources and nutritional delivery methods. The performed nutritional practice was then compared to the LNP.

Results

Out of 103 eligible patients, 46 (45%) patients were included in the study and 15 (33%) patients had follow-up measurements at discharge in addition to baseline measurements. Most patients were acutely hospitalized, n=35 (76%), and multi-trauma was the most common diagnosis group n=12 (26%). The study population had a majority of males n= 28 (61%), a mean (SD) age of 55 (18) years and mean length of stay (LOS) of 6 (5) days.

At admission, 27 (68%) of the population were at high nutritional risk based on PhA and 3 (7%) based on NUTRIC-score. Malnutrition was identified in 4 (9%) patients based on BMI <18.5 kg/m^2, 5 (11%) patients based on MUAC <24.5 cm and 17 (37%) patients with a PhA below 4.1°. A positive correlation was found between PhA and BCM (r=0.853, p=<0.001) and age had an inverse correlation with PhA (r=-0.425, p=0.003) and BCM (r=-0.262, p=0.049). Finally, LOS had a negative correlation with change in PhA (r_s=-0.493, p=0.037) at follow-up. Nutritional adequacy was investigated for 40 patients, whereas 21 patients had a LOS >3 days. According to the LNP, the mean nutritional adequacy after 3 days was 67% for energy and 59% for protein, respectively.

Conclusion

In this observational study we found that nutritional therapy was inadequate in accommodating the estimated requirements. Nutritional practice followed LNP to some degree, however, nutritional therapy was inconsistent for the majority of the study population. We found a high prevalence of nutritional risk in the population and a decline in nutritional status during stay. Though prevalence of malnutrition both on admission and at follow-up varied with anthropometric measurements, several nutritional parameters such as PhA, BCM and MUAC, were decreased at follow-up. We also found that muscle mass represented by PhA decreased with prolonged LOS.

We suggest a dietitian to take part in the interdisciplinary treatment of patients in the intensive care unit to contribute to identifying those at nutritional risk and in securing consistent and adequate nutritional therapy.

Content

List of tables and figures

Abbreviations

%EE	Percentage of Energy Expenditure
APACHE II	Acute Physiology and Chronic Health Evaluation II
BCM	Body Cell Mass
BIA	Bioimpedance Analysis
BL	Baseline
BMI	Body Mass Index
CRRT	Continuous Renal Replacement Therapy
DIPS	Distribuert Informasjons- og Pasientdatasystem i Sykehus
EE	Energy Expenditure
EN	Enteral Nutrition
ESPEN	European Society for Clinical Nutrition and Metabolism
FFM	Fat-free Mass
HUH	Haukeland University Hospital
IBW	Ideal Body Weight
ICCA	Intellispace Critical Care and Anaesthesia
ICU	Intensive Care Unit
LNP	Local Nutritional Protocol
LOS	Length of Stay
MUAC	Mid-Upper Arm Circumference
NRS-2002	Nutrition Risk Screening 2002
NUTRIC	Nutrition Risk in the Critically Ill
ONS	Oral Nutritional Supplement
PHA	Phase Angle
PN	Parenteral Nutrition
SOFA	Sequential Organ Failure Assessment

1. Introduction

Critical illness is a life-threatening condition with a high risk of mortality that requires support of vital organs and specialized care (1). Critical illness from trauma, injury or sepsis requires admittance to a specialized intensive care unit (ICU). Patients admitted to the ICU are either acute or transferred from other hospital units due to worsened condition. Here they receive specialized critical care to avoid death (1).

1.1 The metabolic response to critical illness

Critically ill patients hospitalized in the ICU demand complex and individualized nutritional therapy (2). Trauma leads to a metabolic response that affects individual requirements for energy and nutrients during the critical phases (3). The initial phase after a trauma is referred to as the ebb phase and lasts for 24-48 hours before the transition to the flow phase (3). Metabolic activity drops during the ebb phase, leaving mobilized substrates such as glucose from liver glycogen and free fatty acids from fat tissue unused (3). This changes dramatically in the flow phase when the metabolism is highly affected by an increase in pro-inflammatory cytokines and catabolic hormones, explaining critically ill patients being in a severely catabolic state (3).

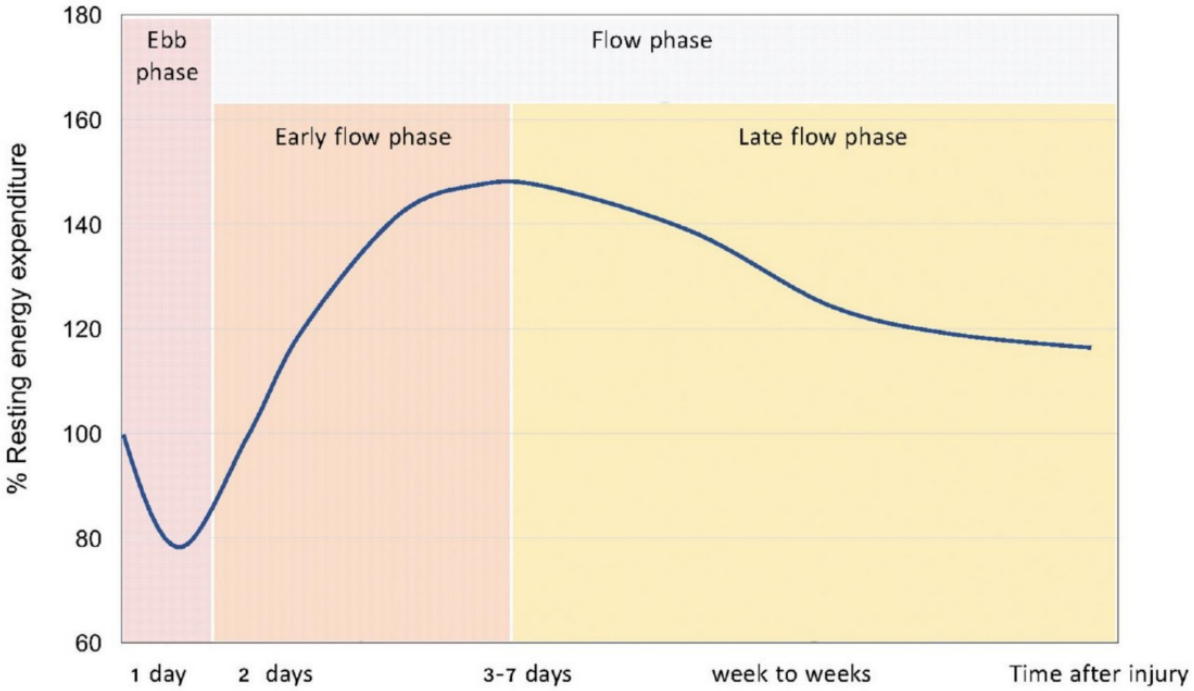

Figure 1: Metabolic response to trauma describing a brief drop in metabolic activity in the ebb phase leading up to a longer lasting hypermetabolic state in the flow phase. Figure used with permission (4).

The metabolic response to critical illness in the flow phase introduces several issues that must be addressed in the nutritional aspect of critical care. The hormonal response starts with the signalling of a stressor to the central nervous system (CNS). The CNS triggers the sympathetic nervous system, leading to the release of catecholamines and pituitary hormones (5). Catecholamine hormones are excreted as adrenergic receptors are activated through CNS, stimulating glucose-synthesizing processes causing a rise in blood sugar. As glycogen stores are quickly depleted, other non-carbohydrate substrates are used to produce glucose through gluconeogenesis to maintain glycaemic control (2). Catecholamines stimulate glycogenolysis, gluconeogenesis and lipolysis alongside increasing the basal metabolic rate (5, 6). An additional consequence of the neuroendocrine response to stress is an increase in glucagon and cortisol. Glucagon and cortisol, alike catecholamines, also increase gluconeogenesis and processes that yield substrates for gluconeogenesis, such as protein proteolysis (3).

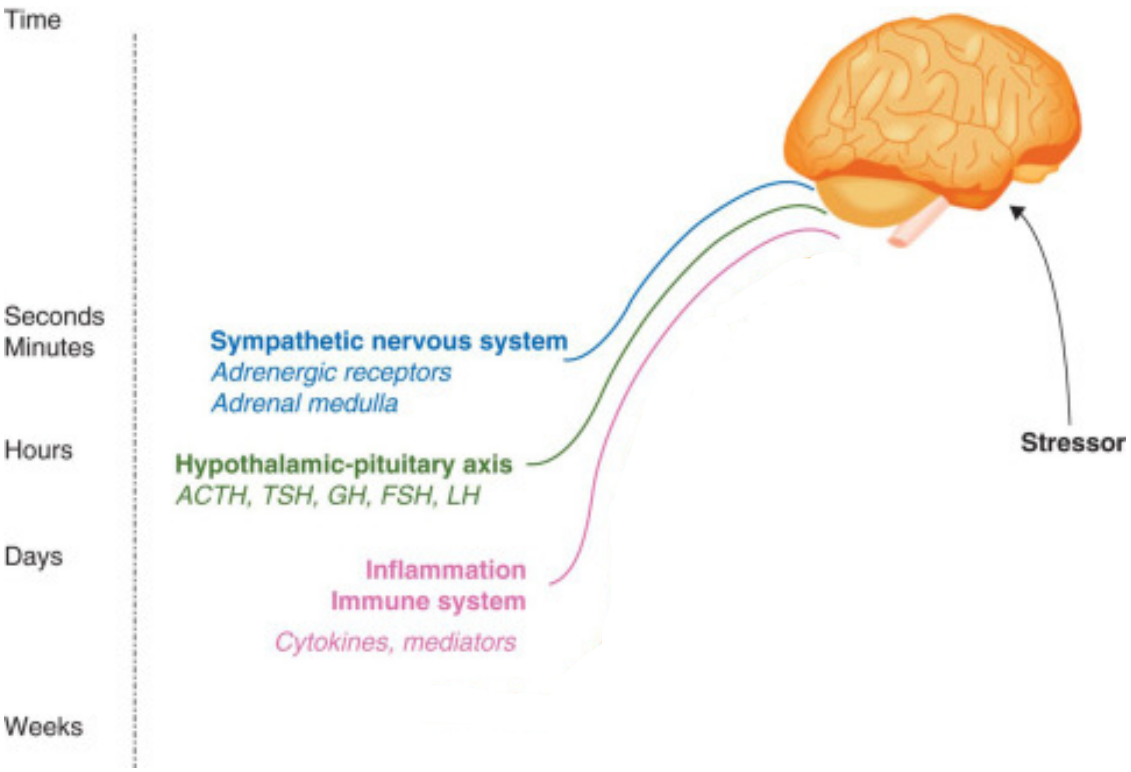

Figure 2: endocrine and immunologic response to trauma. Activation of adrenergic receptors leading to increased levels of catecholamines stimulating catabolic processes. Increased secretion of pituitary hormones including adrenocorticotropic hormone (ACTH) that increases cortisol levels. Figure used with permission (5).

The immunologic reaction to stress and tissue damage is elevated levels of pro-inflammatory cytokines that also contribute to increased glucose-synthesizing activity and the rise in blood glucose. Cytokines, such as tumour necrotic factor, raises levels of both insulin and glucagon, whilst interleukin-1 increases glucose production through gluconeogenesis (6).

In starvation, free fatty acids would eventually be used in ketogenesis to spare muscle protein from being degraded for gluconeogenesis. However, the stress-induced rise of cytokines and catabolic hormones in the flow phase of critical illness increases insulin resistance, therefore inhibiting ketogenesis (7). More muscle protein proteolysis is then needed to supply amino acids as substrates for glucose production in a hypermetabolic state (7). Catabolic hormones and pro-inflammatory cytokines support the proteolysis of muscle proteins, meaning muscle loss is inevitable and also an adverse effect of the hypermetabolic response to critical illness (7). As a result, the hormonal and cytokine response to critical illness leads to hyperglycaemia, glucose intolerance, insulin resistance and muscle proteolysis.

The duration of the highly catabolic flow phase is individual for each patient before reaching a more anabolic recovery state (3). Nutritional status is differentially influenced by the flow phase depending on the duration of this phase, the nutritional status before critical illness occurs and nutritional therapy during hospitalization.
Nutritional therapy has an important influence on long-term outcomes after ICU-care and should aim to be optimized during stay on the ICU, after discharge from the ICU and also for convalescence after hospital discharge (8). However, nutritional therapy has proven to be challenging when nutritional requirements increase at the same time that tolerance for nutritional therapy decreases.

1.2 Malnutrition in the ICU

Though there are different definitions of malnutrition, malnutrition in this context refers to undernutrition defined by anthropometric measurements and an indirect assessment of body composition (9).

Prevalence

Lew et. al (2017) did a systematic review on malnutrition in the ICU and found that malnutrition ranged from 38% to 78% (10). In this review, malnutrition was defined and diagnosed in several studies with an ICU-population by using various nutritional screening

tools, such as Subjective Global Assessment and Mini Nutritional Assessment, before or within 8 hours of admission. In Norway, malnutrition exists in 30% of the adult hospital population and in 40-48% of older patients in hospitals (11).

Causes

Malnutrition in the ICU can be pre-existing due to long-term disease with comorbidities before hospitalization. Other factors that could contribute to malnutrition in the ICU is the patient population being highly catabolic, severity of illness, drug-nutrition interactions, comorbidities, complications such as infections and also difficulties with predicting energy requirement and with supplying nutrition (3). Medical equipment and therapy can also increase or decrease energy needs, increase loss of nutrients, and increase gastrointestinal symptoms (3, 12). Ventilators could alter energy demands by increasing or decreasing respiratory work whilst the use of energetic drugs such as propofol that contributes with 1.1 kcal/ml, can reduce energy needs from nutritional therapy (12). Loss of nutrients is common in continuous renal replacement therapy (CRRT) and can result in loss of electrolytes, protein, water-soluble vitamins, and trace elements (12). Prokinetics, diuretics and corticosteroids can also lead to loss of nutrients. Finally, increased gastrointestinal symptoms is a common difficulty in this patient population and is associated with enteral nutrition (EN) and gut-affecting agents such as paralysing agents, prokinetics and opioids (3). This could therefore complicate nutritional therapy and interfere with accommodating requirements.

Risk factors

Risk factors for malnutrition concern altered nutritional intake, absorption and/or energy requirements. Screening tools for malnutrition target low body mass index (BMI), recent volatile weight loss, reduced nutritional intake, chronic disease, inflammatory disease and expected worsened nutritional status (13, 14). Older age and the presence of multiple comorbidities are also known risk factors for malnutrition in a hospital population (15).

Consequences

Malnutrition is associated with increased risk of ICU readmission, infection, and mortality (10). Prolonged LOS and malnutrition have a clear association with each other, though the cause-effect relation is thought to go both ways (16).

1.3 Prevention of malnutrition

1.3.1 Screening for nutritional risk in a hospital population

Screening and assessment of nutritional status is introduced to recognize those who benefit from individualized nutritional therapy. All patients in Norwegian hospitals should be assessed for the risk of malnutrition at admission using the Nutrition Risk Screening 2002 (NRS-2002) to identify risk factors mentioned. A new simplified screening tool, Malnutrition Screening Tool, is to be introduced in Norwegian hospitals and eventually replace the NRS-2002 as the standard screening tool.

1.3.2 Screening for nutritional risk in an ICU population

NRS-2002 and other tools for assessing nutritional risk using the same criteria are not validated tools for the assessment of patients with critical illness. Information on weight, weight loss and food intake are harder to obtain due to varying level of consciousness. All ICU-patients would be categorized as high risk if assessed using the risk assessment tools for a general hospital population based on severity of illness. This is misleading as not all patients within the ICU are at *high* nutritional risk, stressing the need for a screening tool specifically designed to discover the critical patients that benefit from targeted nutritional therapy (17). A proposed tool to do exactly this is the Nutrition Risk in the Critically Ill (NUTRIC) scoring system. The NUTRIC-score has been developed based on an ICU-population with the intent of screening and identifying those at nutritional risk early enough to improve adverse outcomes such as increased days of mechanical ventilation and mortality (17, 18). Patients that score higher than five are in high nutritional risk and thus have an increased risk of 28-day mortality (19). A NUTRIC-score of six increases the risk with 30% and with even more for higher NUTRIC-scores (19).

1.4 Assessing nutritional status

ESPEN (European Society for Clinical Nutrition and Metabolism)-guidelines state that all patients hospitalized in the ICU for more than 48 hours should be regarded as at risk for malnutrition (20). All patients should also be assessed for risk factors such as low BMI, low nutritional intake, and body composition for existing malnutrition (20).

For acute patients, body weight measurement should be done within 24-48 hours before fluid retention (3). The current weight cannot always be recognized as problematic before seen in

comparison to a previous weight, which could be hard to obtain information about in this setting. Transferred patients rely on hospital staff to weigh them and register weight at least weekly, as according to NRS2002, to be able to discover involatile weight loss during hospitalization (14). Involatile weight loss before hospitalization is a risk factor for both malnutrition and refeeding syndrome (13, 14, 21).

Each patient should also be assessed for body composition to discover patients with a low muscle mass or that are sarcopenic (20). Sarcopenia is primarily recognized as a geriatric loss in skeletal muscle mass and function, however, it is also associated with inactivity, malnutrition and critical illness (22). Sarcopenia can be overseen by assessments solidly based on body weight and BMI; therefore an assessment of body composition is necessary to identify those with a low muscle mass. As there is no gold standard for this examination, there are multiple methods that can be used such as mid-upper arm circumference (MUAC) or bioelectrical impedance analysis (BIA). BIA is a non-invasive and simple method for determining body composition (23). A weak electrical current is sent between electrodes placed in the upper and lower extremities. The main principle of BIA is to identify the part of the fat-free mass (FFM) that is muscle mass in order to assess body composition. This is done by measuring the resistance; opponent of the electrical current sent between electrodes, and comparing this to the reactance; which increases with cell membranes integrity due to capacitance (24). The relationship between resistance and reactance is given with the phase angle (PhA). PhA predicts number of cells and membrane integrity, meaning the proportion of intact cells in FFM (24). The larger amount of cell membranes, or cell mass, the higher the PhA. PhA is therefore a marker we can use to predict muscle mass and has been shown to decrease with increased nutritional risk (23, 25-27). Do Amaral Paes et. al found that using a cut-off of PhA less than 5.5° identified patients in high nutritional risk (NUTRIC >5) with a 79% accuracy (28). As muscle mass varies between sexes and males are expected to have a higher muscle mass, others suggest using sex specific values. Kyle et. al proposed categorizing patients as at nutritional risk when PhA is lower than 5º for males and lower than 4.6º for females (27). Lee et. al suggested using PhA to also categorize into grade of malnutrition using cut-offs of 4.1º for moderate malnutrition and 3.1º for severe malnutrition (23).

Another BIA-parameter of interest is body cell mass (BCM). BCM is the component of the FFM that is metabolically active and contributes to energy expenditure (EE) (29). The close relation between metabolically active tissue and EE means BCM could be a starting point for calculating sufficient nutritional therapy (29). Alternatively to isotope dilution methods that measure BCM directly, equations and BIA can be used to measure BCM bedside (29).

Hydration and fluid shifts are common issues for the validity of BIA-measurements, especially in patients in the ICU who often are overhydrated. However, both PhA and BCM have been shown to be less sensitive to fluid shifts than other BIA-measurements suggesting them to be more reliable parameters for assessing body composition and nutritional risk (23, 27, 29).

1.5 Nutritional demands

The catabolic state increases demands for energy, proteins and other nutrients, and changes dynamically throughout the course of illness (3). There are many methods to determine EE including predictive equations, formulas, direct calorimetry, indirect calorimetry and double-labled water techniques (7). According to ESPEN-guidelines for clinical nutrition in the ICU, EE should be determined using indirect calorimetry (20). Indirect calorimetry measures the use of oxygen (O_2) and production of carbon dioxide (CO_2) and gives a CO_2/O_2-ratio known as the respiratory quotient. Indirect calorimetry is regarded as the gold standard when determining EE (4, 7, 20). In absence of indirect calorimetry, calculations based on oxygen usage from pulmonary arterial catheters or volumetric carbon dioxide measurements by ventilators are favoured over predictive equations of 20-30 kcal/kg/day. The classic rule of thumb of 30 kcal/kg can be translated to be 100% of EE, with 20-25 kcal/kg being around 70-80% of EE. Predictive equations do not take in account individual needs and could mask higher or lower energy demands. This could lead to underfeeding or overfeeding that are both associated with complications (12). Underfeeding can occur due to incorrect calculations or nutritional therapy that deviates from calculated demands. The latter could be due to lack of compliance or remainders of enteral solutions in feeding tubes. Malabsorption, vomiting and/or diarrhoea are also issues that must be addressed. The clearest consequence of underfeeding is a decline in nutritional status that is strongly associated with increased risk of infection, delayed wound healing, prolonged LOS, decreased quality of life, increased morbidity and increased mortality (9, 15). Overfeeding, defined as 110% of energy needs, can

easier occur with parenteral nutrition (PN) and is associated with hyperglycaemia, liver enzyme alterations and increased respiratory load (12).

1.6 Nutritional therapy

Nutritional therapy in ICU patients is complex due to a highly catabolic state, critical illness, increased gastrointestinal symptoms, and decreased tolerance for nutrition (12).

1.6.1 Delivering route

An oral intake in absence of contradictions such as dysphagia (20, 30). Oral intake should be monitored to secure a well-composed intake including energy, proteins, and micronutrients (30). If not, there is indication for supplemental measures with ONS or even EN.

EN can be given using several routes, methods, and solutions. The nasogastric route is preferred, although post-pyloric routes can be initiated in case of intolerance unsolved by prokinetic agents or dysfunction in the upper gastrointestinal tract (20, 30). Long-term demand for EN gives indication for a gastronomy (30). Gastrointestinal intolerance shown as vomiting, diarrhoea, high gastric residual volume and/or abdominal distension is associated with EN (12). These symptoms complicate nutritional therapy with EN and calls for the use of prokinetic drugs and adjustment of both EN-solutions and method of delivery (20). ESPEN advises the use of continuous EN as it is tolerated better than bolus EN, provides a more stable blood sugar and reduces diarrhoea, gastric residue volume and superior mesenteric artery blood volume (20). Though EN is associated with increased gastrointestinal intolerance, EN is favoured over PN in absence of contradictions such as intestinal paralysis, obstruction or massive aspiration (2). There is no difference in 30-day mortality in the ICU when comparing EN and PN (31). However, PN has multiple negative effects on the liver and increases risk of infection, hyperglycaemia, electrolyte disturbances and intestinal atrophy (2, 3). EN is therefore first choice when administering nutritional support and rather supplemented with PN when necessary to prevent malnutrition or worsen already existing malnutrition (3). As EN often is inadequate in reaching energy targets, PN should be initiated within 3-7 days if EN is insufficient in delivering >60% of recommended intake (2, 20).

1.6.2 Composition: energy and protein

The most appropriate amount and composition of nutritional support to critically ill patients has been and still is an ongoing debate (3). The challenge is in finding a balance between enough energy, protein, and nutrients to support the patient in an initial phase, whilst avoiding a larger burden on organs and metabolism from excessive amounts. According to ESPEN-guidelines, nutrition in the early phase of acute illness should be hypocaloric and not exceed 70% of EE the first 24-48 hours. If EE is estimated with indirect calorimetry, total energy can be increased progressively after day 3 towards 80-100% of EE. However, hypocaloric feeding is recommended for the whole first week when predictive equations are used to estimate EE due to the fear of overfeeding (20). It is important that non-nutritional energy sources, such as propofol as a sedative and trisodium citrate in CRRT, are considered when calculating energy amounts.

Hypermetabolic ICU-patients have increased anabolic resistance and proteolysis of muscle protein (20). As loss of muscle mass is expected in the ICU and can be up to 1 kg per day, protein requirements are higher in intensive care patients (20). The guidelines from ESPEN advise a protein intake of 1.3 g/kg/day, though previous guidelines advised 1.2-1.5 g/kg/day. Protein requirements should be individually assessed and do not necessarily parallelly increase with energy requirements (3, 20). Protein requirements can be hard to accommodate due to standard compositions in feeding solutions (12). Protein should be given progressively and is hard to supplement alone without also supplementing significantly more energy (20). Protein-enriched foods, ONS and high-protein enteral solutions should therefore be considered to reach protein targets.

The benefits of a high-protein nutritional therapy have been documented in several studies when not associated with overfeeding (20). A negative protein balance is expected in this patient group, increasing the loss of muscle mass (3). Muscle loss can be estimated by comparing protein intake with urine urea and indicates catabolism. Individualized nutritional therapy can then be roughly designed to meet the estimated protein loss in these patients (12).

1.7 Nutrition protocols

In order to manage the dynamic metabolism of ICU-patients, local unit-specified protocols are important to secure safe and individualized nutritional therapy (12). Nutritional protocols are implemented to simplify sufficient nutritional support as early as possible (3, 12). The

ICU at Haukeland University Hospital (HUH) has a nutritional flowchart illustrating their own local nutritional protocol (LNP) (appendix 2). Important elements in the LNP are the choice of nutritional solutions to supply sufficient energy and protein intake, methods, timing, and supplemental interventions.

1.8 Nutritional calculator

Recently the ICU at HUH has approved a nutritional calculator that allows prescribing enteral nutrition based on individual energy- and protein needs, easier. The tool is locally designed to simplify calculations of energy and protein requirements for patients admitted to the ICU (appendix 3). The calculator only needs the weight and height of the patients meaning sex, age, disease, and comorbidities are not considered.

1.9 Dietitians in the ICU/ Importance of this project

The nutritional therapy of critical patients is extremely complex and involves solving many problems. Although algorithms and nutritional standard of protocols improve nutritional therapy, a dietitian trained in nutritional intensive care has shown to provide significantly elevated nutritional therapy (32, 33). Dietitians possess knowledge and practical training in solving nutritional obstacles that has been reported to be problematic for physicians and nurses to solve (34). The ICU at HUH has to this date no dietitian with affiliation to the ICU. Physicians can freely refer patients to a dietitian, though this is rarely done as stated by those who work at HUH. However, patients within the ICU demand closer monitoring than the general population meaning the ICU should have their own dietitian. Dietitians should contribute to the multidisciplinary treatment of critical patients by estimating nutritional requirements dynamically and in optimizing nutritional therapy throughout hospitalization.

Research question

The main objective was to investigate the nutritional status at admission and how this changed during stay on the intensive care unit. Secondary objectives were to estimate nutritional requirements, to map nutritional therapy and to evaluate if the nutritional practice was according to the LNP at HUH.

2. Method

2.1 Study design

The project has a prospective, observational study design and was conducted in the intensive care unit (ICU) at Haukeland University Hospital (HUH).

2.2 Study population and setting

2.2.1 Setting

The project was set at HUH in Bergen, Norway. HUH is a university hospital in Western Norway with local, regional, and also national function. The ICU has 11 beds and is one of four units that handle critically ill patients at HUH.

2.2.2 Study population

Patients hospitalized in an ICU are the target population of this project. This includes both those acutely admitted, and patients transferred from other hospital units with the exception of transfers from other ICUs.

2.2.3 Enrolment

Study participants were enrolled upon arrival to the ICU at HUH between 1st August 2022 and 31st of October 2022. Inclusion criterion were all patients over 18 years of age. Exclusion criteria were those who were contagious or had received treatment on another ICU prior to the ICU at HUH.

2.2.4 Consent

All recruitment was done by the master student. Patients that were conscious and/or next of kin were informed verbally and were handed an informational pamphlet explaining the aim of the project (appendix 1). Participants unable to give consent were recruited using consent from next of kin. Those who neither could give consent themselves or had accessible next of kin were contacted by the master student after discharge from the hospital. They were informed with the information pamphlet sent to them digitally. They could then give consent digitally using Visma Addo.

In a later stage of the project after data collection was finished, the master student was given permission to use unidentifiable data independently of consent given by the patients themselves or next of kin.

2.3 Data collection

Collected data included patient information to assess nutritional status and individual nutritional needs alongside nutritional therapy given on the ICU to map and compare to a local nutritional protocol (LNP) and international guidelines. Patient data was collected from digital patient records and charts or measured by the master student (table 1). HUH uses DIPS (Distribuert Informasjons- og Pasientdatasystem i Sykehus) for patient records on all hospital units. The chart system used on the ICU at HUH is ICCA (Intellispace Critical Care and Anesthesia). Charts have data without detailed descriptions, for example infusion rate of a given enteral solution, whilst patient records often have more detailed information such as documentation of intolerance or reasons for switching enteral solutions.

Table 1: Sources of data in data collection

	DIPS/ICCA/ nutritional calculator	Master student
Nutritional status	Weight	MUAC[5]
	Height	PhA[6]
	BMI[1]	BCM[7]
	SOFA[2]-score	APACHE II-score
	Data for APACHE II[3]-score	NUTRIC-score
	Data for NUTRIC[4]-score	
Nutritional requirements	Energy requirements	Protein requirements
	Data for calculation protein	
Nutritional therapy	Timing	Protein content
	Method for intake	Percentages of nutritional adequacy
	Nutritional source	Mean nutritional adequacy
	Amount	

[1] Body Mass Index
[2] Sequential Organ Failure Assessment
[3] Acute Physiology and Chronic Health Evaluation
[4] Nutritional Risk in the Critically Ill
[5] Mid-Upper Arm Circumference
[6] Phase Angle
[7] Body Cell Mass

Table 2: Necessary data for APACHE II- and NUTRIC-scores

Scores	Data needed for scores
APACHE II[1]	Age
	Temperature
	Mean arterial pressure
	pH
	Heart rate
	Respiratory rate
	Sodium
	Potassium
	Haematocrit
	White blood count
	Glasgow Coma Scale
	FiO_2[3]
	Acute renal failure?
	History of organ failure?
	Covid-19?
NUTRIC[2]	Age
	APACHE II-score
	SOFA[4]-score
	Number of comorbidities
	Days in hospital prior to ICU[5]

[1] Acute Physiology and Chronic Health Evaluation

[2] Nutritional Risk in the Critically Ill

[3] Fraction of inspired oxygen

[4] Sequential Organ Failure Assessment

2.4 Methods

2.4.1 Nutritional status

The baseline nutritional status and development of nutritional status throughout the stay on the ICU was assessed with anthropometric measurements and an indirect assessment of body composition using BIA alongside a screening for nutritional risk using the NUTRIC-score. The anthropometric and BIA measurements were done momentarily after enrolment and repeated at discharge if LOS surpassed 3 days.

Anthropometric measurements and BIA

The anthropometric measurements of interest were body weight, height, BMI and MUAC. Data on weight and height was taken from patient charts and records. The nurses were responsible for performing the weight measurement and registering this in records. Weight was measured daily using a hospital bed with a built-in weight. Initial nutritional status was based on weight and height registered at admission that were either self-reported, estimated or measured. BMI was automatically calculated in charts based on the weight and height registered. BMI-assessment was based on World Health Organizations classification (35).

Change in weight was calculated by the master student and based on weight registered upon arrival and the last weight registered before patients were transferred.

An indirect assessment of body composition and assessment of muscle mass was done by using MUAC and BIA. Both MUAC and BIA were measured by the master student during the first clinical visitation after inclusion. The MUAC was measured at the half point between the acromion of the shoulder and the olecranon process at the elbow, using a measuring tape. The measurement was strived to be taken with a 90-degree bend in the elbow with the arm held parallel to the body. Patients that were not accessible on the left side were measured on the right arm. All MUAC-measurements were taken with the patients lying down. MUAC-measurements were assessed using proposed reference values where <24.5 cm is considered the cut-off for malnutrition (36).

Body composition was determined by using a bioimpedance device and electrodes (BIA 101 Anniversary Sport Edition, Akern). Electrodes were placed in pairs on one hand and one foot on the same side of the patient. One electrode pair was placed on the knuckle and wrist,

alongside one electrode placed on the toes and another on the front face of the ankle. PhA and BCM were measured with the intention of assessing nutritional status and comparing to a secondary measurement before discharge or termination of treatment. Both PhA and BCM were calculated by the bioimpedance device. Patients with amputations were excluded from this particular measurement (n=1). A routine check of the bioimpedance device was done between patients using resistors and capacitors with known values to ensure validity. As reference values for PhA and BCM remain elusive, assessment of nutritional status depend on which cut-off values are used. Both general and sex-specific cut-off values have been proposed when using PhA to assess nutritional status.

Table 3: reference values for high nutritional risk and malnutrition

	BMI[1]	MUAC[2]	PhA[3]	BCM[4]	NUTRIC
Cut-off	<18.5 kg/m^2 (35)	<24.5 cm (36)	<5.5° (28)	≈ 40% (37) of IBW[5]	Score > 5
Males			<5.0° (27)		
Females			<4.6° (27)		

[1]Body mass index
[2]Mid-upper arm circumference
[3]Phase angle
[4]Body cell mass
[5]Ideal body weight

NUTRIC-score

Each patient was retrospectively scored with a NUTRIC-score upon arrival, and at dismission for eligible patients. The NUTRIC-score is based on age, comorbidities, hospitalization days prior to admission to the ICU and two scoring systems; Sequential Organ Failure Assessment (SOFA) and Acute Physiology and Chronic Health Evaluation II (APACHE II). The SOFA-score is a prediction of organ function based on lab and clinical data for 6 organ systems: respiratory, hepatic, cardiovascular, neurological, renal and coagulation (38). The NUTRIC-score was based on a SOFA-score assessed by a physician upon arrival to the ICU and registered in patient charts. APACHE II is a score used for newly admitted ICU-patients and estimates mortality and prognosis (39). The APACHE II-score was calculated by the master student based on measurements registered in charts. This included serum sodium, -potassium, -creatinine, white blood cell count, haematocrit and pH alongside parameters reflecting respiration, circulation, consciousness, and other organ function. Consciousness was

measured by the staff on the ICU using the Glasgow Coma Scale and documented in patient charts.

The initial SOFA-score and APACHE II-score given at admission was used to assess NUTRIC-score. Other information concerning age, comorbidities, and days in hospital prior to ICU was found in patient records. Interleukin-6 (IL-6) was originally a part of the NUTRIC-score, though it is not commonly measured at HUH. IL-6 is therefore left out by many in the assessment using the NUTRIC-score without it affecting the validity of the tool (40). NUTRIC-scores were not given to those who had not given consent to review their patient records at this point of the data collection before consent was given on behalf of the whole population.

2.4.2 Nutritional requirements

In this project, individual nutritional requirements were estimated by the master student using the nutritional calculator that has been implemented on the ICU at HUH. Weight and height registered at admission was plotted in the calculator which then estimated individual requirements of energy and protein. Calculations are based on the LNP and follow ESPEN-guidelines for nutritional therapy of critically ill patients. The calculator gives an interval of recommended total energy ranging from 20-30 kcal/kg per day, leaving room for clinical judgement as to which phase of acute illness the patient is in. The calculator also gives an interval for recommended protein intake based on body weight. For patients exceeding BMI 30 kg/m^2, both energy and protein requirements were based on ideal body weight (IBW) given at a BMI of 20-25 kg/m^2 as recommended by the calculator. As the most recent ESPEN-guidelines recommend 1.3 g protein per kg body weight per day, this was considered the protein target for this population. The nutritional requirements that were prescribed were estimated by an ICU physician and were not always according to estimations based on the calculator.

2.4.2 Nutritional therapy

Data on nutritional therapy was retrieved from patient charts in ICCA. This includes information about timing, amounts and route; oral intake, enteral nutrition, parenteral nutrition, glucose solutions, non-nutritional energy sources and also medicinal treatment of gastrointestinal symptoms. In-depth details, such as describing reasons for any changes in

nutritional therapy or management of gastrointestinal symptoms related to administration of nutrition, were found in DIPS.
Energy intake was calculated based on information from individual charts from the first whole 24 hour-day of stay in the ICU. Patients' records were then used for background information such as why a patient had altered nutritional therapy and difficulties that arose with supplying nutrition. Total energy and protein intake was compared to nutritional, requirements and given in percentage of nutritional adequacy.

Energy from oral intake was estimated by nurses in charts and calculations were checked by the master student if the intake was described in detail in DIPS. Protein intake from oral intake was calculated using an information sheet used at HUH, listing protein content in different food types on offer. Some staff described oral intake with fractions such as half etc. Calculations of oral intake were then done based on this.

Calculations of energy from enteral and parenteral solutions were done based on product information from suppliers of the solutions. Total energy and protein intake was calculated by the master student using both the nutritional calculator and by calculating manually.

2.3.4 Nutritional intake compared to local nutritional protocol

The evaluation of compliance to LNP was assessed by method, timing, and adequacy.
Data concerning nutritional therapy, such as energy source, nutritional content, amounts, method etc. was compared to the locally implemented nutritional protocol and the ESPEN-guidelines on clinical nutrition in the intensive care unit.

When calculating means on population-level, patients were excluded if they did not meet criteria for the mean that is presented. All patients that had a LOS <3 days were not included in calculations of means for the first three days on population-level, in order to calculate a mean that is most precise and representable for the population.

2.4 Ethics

This project was assessed as a quality project by the Regional Committee for Medical and Health Research Ethics (REK Vest). The project was approved by the data protection official (personvernombudet) at HUH and data collection was done according to the ICUs data and information security routines.

Collected data was saved on a SAFE-server connected to the University of Bergen (UiB) protected by a two-factor authentication and password only known by the master student handling the data. Sensitive personal information such as social security number, name and other private information were not collected. Consent forms were locked in with a code only know to the student and project assistant/specialist nurse who works on the ICU and will be kept for three years according to research guidelines before being destroyed. Consent was given from 29 patients to use the data collected in this project. The research manager of anaesthesia and intensive care gave consent to use data on behalf of those where consent was difficult to attain. The patients could at any point of the project deny participation or withdraw consent without this impacting medical treatment.

2.5 Statistics

Statistics were done using SPSS (Statistical Package for Social Sciences). Descriptive statistics of specifically means, ranges and standard deviations of measurements, requirements and nutritional intake were of interest. A correlation analysis of parameters PhA, BCM and age at baseline was done using a one-tailed Pearson's analysis. Also, correlation of change in PhA and BCM at baseline with LOS was done using a one-tailed Spearman analysis.

3. Results

In the period of data collection in August 2022 – October 2022, 103 patients were admitted to the Intensive Care Unit (ICU) at Haukeland University Hospital (HUH). Of these, 57 (55%) were excluded from the study population for various reasons such as young age (n=16), contagious isolation (n=15), hospitalized during weekend (n=18), received ICU-treatment elsewhere (n=3) or death within 24 hours (n=5). A total of 46 patients were included and assessed for nutritional status. BIA and MUAC was performed on all included patients except one amputee. Information on weight and height was registered in the patient records of 43 (94%) of the included patients. NUTRIC-score was assigned to 27 patients at admission and 16 at discharge. Finally, 15 (33%) of the included patients had follow-up measurements on the day of discharge or prior to death. Lack of measurements at discharge was due to a LOS <3 days or fail to follow-up due to practical difficulties before transfer or death. See figure 3.

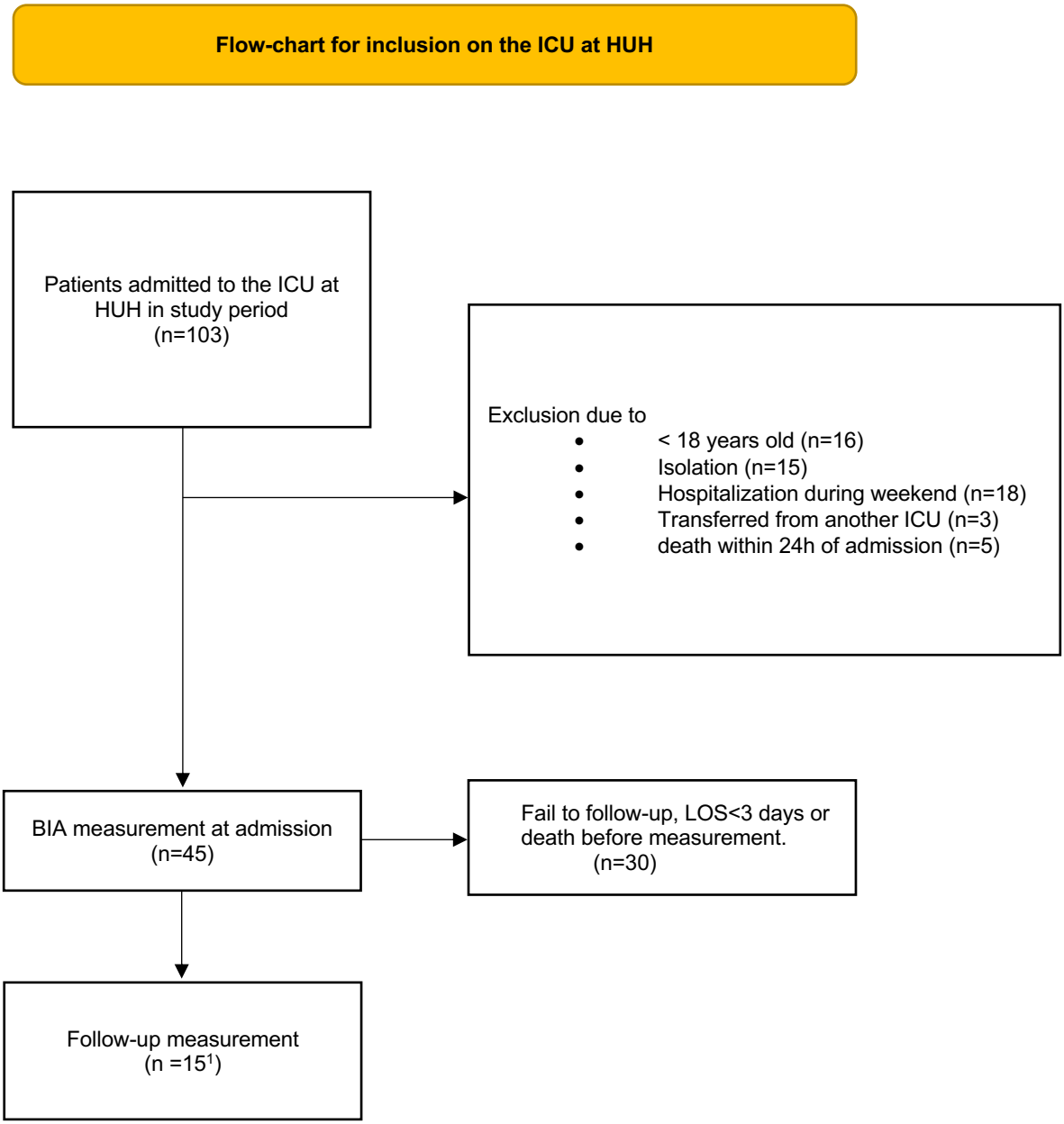

Figure 3: Flowchart for inclusion.

[1] Errored BIA-measurement of one patient excluded

3.1 General

Of the 46 patients included, 18 (39%) were female and 28 (61%) were male with a mean (SD) age of 55 (18) years for the whole population. A total of 35 (76%) patients were acutely hospitalized and 11 (24%) patients were already hospitalized when they were transferred to the ICU, nine (20%) patients died on the ICU during this period. The patients were categorized into diagnosis groups with multi-trauma (n=12, 26%) being the most frequent diagnosis group admitted during this period. LOS ranged from one day to 30 days, with a mean (SD) of 6 (5) days. Those with the shortest LOS (≤3 days) were patients needing post-operative observation after surgery, acute patients that needed stabilizing or patients in need of a brief ICU-treatment before being transferred to other units. Mean (SD) days of mechanical ventilation was 4 (5) days (table 4).

Table 4: General characteristics, n=46

	n (%)
Female	18 (39)
Acute hospitalization	35 (76)
Deaths	9 (20)
Diagnosis	
Circulatory	1 (2)
Gastrointestinal	8 (17)
Multi-trauma	12 (26)
Neurological	7 (15)
Renal	2 (4)
Respiratory	11 (24)
Sepsis	5 (11)
	Mean (SD[1]), range
Age	55 (18), 21-78
Length of stay, days	6 (5), 1-30
Ventilation, days	4 (5), 0-22

[1] Standard Deviation

3.2 Nutritional status

3.2.1 Admission

The mean (SD) weight of the population was 76 (17) kg; height: 173 (10) cm; BMI was: 25.2 (5) kg/m^2 and MUAC: 31(4) cm. Mean (SD) PhA was 4.9 (1)° and BCM: 25.4 (9) kg.
Males in the study population had a mean (SD) weight: 82 (17) kg; height: 178 (7) cm; BMI: 25.6 (4.5) kg/m^2 and MUAC: 31.8 (3.8) cm. Females had a mean (SD) weight: 67 (13) kg; height: 165 (9) cm; BMI: 24.7 (5.7) kg/m^2; and MUAC: 30 (4.5) cm.
BIA-measurements of males showed a mean (SD) PhA: 5 (1.4)° and BCM: 27.9 (8.6) kg, whilst females had a mean (SD) PhA: 4.7 (1.7)° and BCM: 21.8 (8.1) kg.
BCM contributed to 33% of the mean body weight. In females, BCM contributed to 32.5% of the mean body weight and 34% of the mean body weight in males. Anthropometry and BIA measurements are shown in table 5.

A one-tailed Pearson correlation analysis of PhA and BCM showed a positive correlation ($r= 0.853$, $p <0.001$). The same type of correlation analysis also showed that age had a negative correlation with both BCM ($r=-0.262$, $p=0.049$) and PhA ($r=-0.425$, $p=0.003$).

The general populations' BMI borders the category for overweight and had a range of 15.8 kg/m^2 – 38.4 kg/m^2. A total of 4 (9%) patients were malnourished based on their BMI, all of them were females. Based on proposed cut-off values for MUAC in adults, the general population was within the overweight category. When separated by sex, the males had a mean within the obese category and the females in the normal category. Individually, 5 (11%) patients had a MUAC categorizing them as malnourished, four of these were females that were also categorized as malnourished based on their BMI.

A total of 27 (68%) patients were at high nutritional risk at admission following general cut-off values (PhA <5.5º). Following proposed sex-specific cut-offs, a total of 20 (44%) patients and were at nutritional risk at admission: 12 males and eight females.
Using cut-off values from Lee et. al, 11 (24%) patients were moderately malnourished (PhA<4.1º), and 6 (13%) patients were severely malnourished (PhA <3.1º) at admission. Three of the patients defined as severely malnourished by PhA were also defined as malnourished using BMI and MUAC. One patient categorized as severely malnourished

based on PhA was also categorized as malnourished based on MUAC but not BMI. One female bordered malnutrition based on BMI and MUAC, but not based on PhA-value.

Table 5: BIA and anthropometric measurements at admission

	Total		Female		Male	
	n	Mean (SD[1]), range	n	Mean (SD), range	n	Mean (SD), range
Weight, kg	43	76 (17), 46-130	17	67 (13), 46-94	26	82 (17), 49-130
Height, cm	43	173 (10), 144-190	17	165 (9), 144-180	26	178 (7), 161-190
MUAC[2], cm	46	31.0 (4), 19.0-37.5	18	30 (4.5), 21-38	28	31.8 (3.8), 23-37
BMI[3], kg/m^2	43	25.2 (5), 15.8-38.4	17	24.7 (5.7), 15.8-36.7	26	25.6 (4.5), 18.7-38.4
PhA[4], °	45	4.9(2), 1.5-7.7	18	4.7 (1.7), 1.5-7.7	27	5.0 (1.4), 2.3-7.4
BCM[5], kg	45	25.4 (9), 5.6-43.8	18	21.8 (8.1), 5.6-40.3	27	27.9 (8.6), 11.5-43.8

[1] Standard deviation
[2] Mid-upper arm circumference
[3] Body mass index
[4] Phase angle
[5] Body cell mass

3.2.2 Discharge

Of the 46 included patients, 15 (33%) had follow-up measurements before discharge from the ICU or prior to death. This population consisted of 9 (60%) males and 6 (40%) females, with sepsis as the most frequent diagnosis (n=3). There was a total of 10 (67%) acute patients and 12 (80%) patients from the follow-up group survived their stay on the ICU. The mean (SD) age was 55 (15) years and mean (SD) LOS was 10 (6) days.

3.2.3 Change during ICU-stay

The follow-up measurements were compared to baseline measurements, (table 6 and 7). Data from the BIA measurement of one patient was excluded due to a measurement error. Mean (SD) difference in weight was -0.4 (4.6) kg, meaning the average weight loss was 400 g during stay. Mean (SD) difference in MUAC was -0.7 (1.0) cm; mean (SD) difference in BCM was -3.3 (2.1) kg and -0.3 (0.7)° in PhA.

The follow-up population had a mean PhA of 4.7º at admission and 4.3º at discharge. Following the cut-off of 5.5º, 11 of 15 patients in this population (73%) were at high nutritional risk when admitted to the ICU. This mildly increased to 11 of 14 patients (79%) at discharge. At discharge, 2 (13%) patients were moderately malnourished and 4 (27%) were severely malnourished based on PhA. Of these 6 (40%) patients, 5 (33%) were already malnourished upon arrival at the ICU, whilst one patient (7%) became malnourished during LOS of six days. A one-tailed Spearman correlation analysis showed that the change in PhA correlated with LOS (r_s =-0.493, p =0.037), meaning a larger decrease in PhA was seen in those with a longer stay on the ICU.

The mean (SD) change in BCM was -3.3 (2.1) kg and -5 (4) % of actual body weight (table 7). BCM also negatively correlated with longer LOS (r_s =-0.401, p =0.078).

Table 6: Baseline measurements compared to measurements at follow-up

Patient	LOS[1], days	BW[2], kg		MUAC[3], cm		BCM[4], kg/% of BW		PhA[5], º	
		BL[6]	FU[7]	BL	FU	BL	FU	BL	FU
1	11	82	73	36	33	42.9/52	38.0/41	7.4	7.0
2	5	68	66	26	26	17.4/26	16.8/25	2.8	3.9
3	8	80	76	30	28	19.7/25	15.8/21	2.9	3.1
4	7	91	89	31	30	30.4/33	25.6/29	5.2	4.1
5	30	100	95	32	30	26.1/26	20.9/22	5.1	4.3
6	7	90	90	34	34	25.1/28	24.9/28	5.7	5.6
7	8	65	62	25	24	17.7/27	17.0/27	5.0	4.7
8	12	92	94	35	34	33.4/36	28.9/31	4.8	4.7
9	9	67	66	31	31	30.5/46	25.3/38	6.0	5.4
10	12	79	81	31	29	27.4/35	23.6/29	5.1	4.3
11	8	85	93	31	31	27.0/32	Error	4.8	Error
12	8	100	98	38	34	28.8/29	27.0/28	5.8	5.5
13	17	54	58	33	31	18.4/34	13.3/23	3.4	2.2
14	8	78	78	31	31	20.6/26	14.0/18	3.6	2.8
15	13	49	58	21	19	10.7/22	10.4/18	3.1	2.9
Mean (SD[8])	10 (6)	79 (15)	79 (14)	31 (4)	30 (4)	25.1(8)/32(8)	21.5(7)/27(7)	4.7 (1)	4.3 (1)

[1] Length of stay
[2] Body weight
[3] Mid-upper arm circumference
[4] Body cell mass
[5] Phase angle
[6] Baseline
[7] Follow-up
[8] Standard deviation

Table 7: Mean differences in measurements at follow-up compared to baseline

	n (%)	Mean (SD[5]), range
ΔWeight, kg	15 (100)	-0.4 (4.6), -9.0 – 9.0
ΔBMI[1], kg/m^2	15 (100)	+0.6 (1.8), -3.5 – 2.9
ΔMUAC[2], cm	15 (100)	-0.7 (1.0), -3.0 – 0.0
ΔPhA[3], °	14 (93)	-0.3 (0.7), -1.2 – 1.1
ΔBCM[4], kg	14 (93)	-3.3 (2.1),-6.6 – (-0.2)
ΔBCM, %	14 (93)	-5.0 (4), -11.0 – 0.0

[1] Body mass index
[2] Mid-upper arm circumference
[3] Phase angle
[4] Body cell mass
[5] Standard deviation

3.2.4 NUTRIC-score

The mean (SD) NUTRIC-score at admission was 3 (2) out of a possible score of 12. Three patients had a score of five or more and were therefore at high nutritional risk when admitted to the ICU. The highest score given was six and was received by three patients, two of these were later included to the follow-up group. At discharge, the mean (SD) NUTRIC-score was also 3 (1.4), no patients had a score higher than five. Compared to NUTRIC-scores from admission, mean (SD) difference in NUTRIC-score was minus 1 point for those who were scored both at admission and discharge.

Table 8: NUTRIC-score at admission and discharge, n=46

	n (%)	Mean (SD[2]), range
NUTRIC[1] admission	27 (59)	3 (2), 0 – 6
NUTRIC > 5	3 (7)	
NUTRIC discharge	16 (35)	3 (1.4), 0 – 4
NUTRIC > 5	0 (0)	
ΔNUTRIC	16 (35)	-1 (1.4), -3 - 2

[1] Nutritional Risk in the Critically Ill
[2] Standard deviation

3.3 Individual needs

Energy requirements were rounded up to closest 50 kcal and protein requirements to the closest round digit.

3.4 Nutritional therapy

3.4.1 General

The nutritional therapy given to patients during the study period was registered for 40 patients. The remaining six patients were omitted due to transfer to another unit within 24 hours (n=4) or having a palliative direction of treatment (n=2).

3.4.2 Method of nutritional therapy

The delivery route of nutritional therapy was oral, enteral through a nasogastric tube or a percutaneous endoscopic gastrostomy and/or parenteral through a central venous line.

In total, 8 (20%) patients had an oral intake of nutrition including regular food and oral nutritional supplemental (ONS) drinks, 4 (10%) of these received no other source of nutrition. The typical foods offered were sandwiches, energized soups, ONS products and dinners from the hospital menu. Amongst these four patients, two were transferred within 48 hours and two had an energy intake <70% of EE after 48 hours. Of the two with a LOS > 48 hours, one of them had a mean (SD) oral intake of 26 (11)% and the other had 32 (8)% , both over four days.

EN was received by 23 (58%) patients either alone as the sole nutritional source (n=14), combined with PN (n=8) or combined with an oral intake (n=2). Those receiving EN from admission was started on continuous EN within 48 hours. Eleven different solutions were given, energy content ranged from 1 kcal/ml to 2 kcal/ml and protein ranged from 3,8 g/100 ml to 10 g/100 ml solution. The most common enteral solution used was a standard solution of 1 kcal/ml with 3,8 g protein per 100 ml (table 9).

Parenteral nutrition was given as a primary source or as a supplement to 10 (25%) patients. Four (17%) patients received PN supplemental to EN on day five, after receiving supplemental glucose between day two and four due to insufficient EN (<60%). PN was also initiated on day five for one patient with contradictions for EN that had received solely

glucose for four days. The remaining four patients received PN within 48 hours as the sole nutritional source.

In addition, 35 (88%) patients received a glucose solution either while waiting for a nutritional plan to be initialized or as a part of an initialized nutritional therapy to prevent hypoglycaemia. The glucose solutions had different concentrations of 5% (200 kcal/l), 10% (400 kcal/l) or 20% (800 kcal/l). Non-nutritional energy sources were also registered, 22 (55%) patients received propofol as a sedative and 2 (5%) received citrate as part of CRRT (table 10). While citrate contributed with around 200 kcal per day, propofol contributed with a mean of 260 kcal with a range of 20-589 kcal per day.

Table 9: Enteral solutions used during the study period. n = patients that received the given solution of the 22 who received EN. Some patients received several solutions during stay.

	n (%)	Energy/ml	Protein/100ml
Original	16 (73)	1 kcal	3.8 g
Original fibre	2 (9)	1 kcal	4.0 g
Low sodium	1 (5)	1 kcal	4.0 g
Protein plus	1 (5)	1.25 kcal	6.3 g
Protein advanced	5 (23)	1.28 kcal	7.5 g
Survimed	5 (23)	1.33 kcal	4.5 g
Energy	15 (70)	1.5 kcal	5.6 g
Energy fibre	7 (32)	1.5 kcal	5.6 g
Diben High Protein	2 (9)	1.5 kcal	7.5 g
High energy	9 (41)	2 kcal	10 g
High energy fibre	3 (14)	2 kcal	10 g

Table 10: Method of nutritional intake and timing of initiation. Some patients had combinations of different methods, n = 40.

	n (%)	< 48h[1]	48h > 3 days	3-5 days	> 5 days
Oral nutrition	8 (20)	6 (15)	-	-	2 (5)
Enteral nutrition	23 (58)	11 (28)	9 (23)	1 (3)	2 (5)
Parenteral nutrition	10 (25)	4 (15)	-	5 (13)	1 (3)
Combination (oral/enteral/parenteral)	9 (23)	1 (3)	-	2 (6)	6 (15)
Propofol	22 (55)				
Citrate	2 (5)				
Glucose	35 (88)				

[1]Hours

3.4.3 Energy intake

Estimated energy requirements calculated using the nutritional calculator were compared to registered energy intake. The distribution of nutritional adequacy throughout stay is presented in table 11 and 12. A total of 24 patients had a LOS ≥3 days and therefore were included in the mean for energy requirements met from day one to day three in the ICU. For the first three days, nutritional adequacy was <25% for six patients, 25-50% for 10 patients, 51-70% for seven and 71-100% for one patient.

The mean nutritional adequacy for day four until to discharge was based on 21 patients. In this period, a total of 10 patients met energy requirements with <70%. This was distributed with one patient meeting energy requirements with <25%, four met theirs with 25-50% and five with 51-70%. Energy requirements of over 70% for 10 patients meeting their energy requirements with 71-100% and one patient with a mean adequacy over 100%. The mean nutritional adequacy during the total LOS was <25% for 15 patients, 25%-50% for 11 patients, 51%-70% for nine patients and 71%-100% for five patients.

Table 11: distribution of nutritional adequacy throughout stay

	Day 1-3	**Day 4- discharge**	**Mean total**
	n%	n%	n%
n	24 (100)	21 (100)	40 (100)
<25%	6 (25)	1 (5)	15 (38)
25-50%	10 (42)	4 (19)	11 (28)
51-70%	7 (29)	5 (24)	9 (23)
71-100%	1 (4)	10 (48)	5 (13)
>100%	-	1 (5)	-

Underfeeding defined as <70% occurred at least once in 19 of 21 patients (90%) that had a LOS surpassing three days. Overfeeding, defined as 110% of estimated energy requirements, was seen in six (29%) patients with a LOS surpassing three days.