



# A Different Approach to the Nutritional Therapy in Intensive Care Units: Nutrition Software (ICNUS)

Yoğun Bakımda Nütrisyon Tedavisine Farklı Bir Yaklaşım: Nütrisyon Yazılımı (ICNUS)

Mois Bahar

VKV American Hospital, General Intensive Care Unit, İstanbul Turkey

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Critically ill patients receive nutritional support in addition to extensive organ support therapies in the intensive care units. The transcription of the data obtained by multiple devices from a wide spectrum of usage areas is a challenging process and is prone to errors. Software specifically designed for usage in intensive care units do offer numerous advantages. Primarily, it facilitates to improve the management of time and workflow for the benefit of patients. Therefore, we believed that a different approach was needed for the nutritional regime of our critically ill patients. Following nearly 2 years of research, we developed and implemented the Intensive Care Nutrition Software (ICNUS), which is explained in this article.

**Keywords:** ICNUS software, intensive care, nutrition

Yoğun bakım birimlerinde yoğun organ destekleri almakta olan hastaların aynı zamanda nütrisyon tedavileri de birarada yürütülmektedir. Çok miktarda kopuk kopuk farklı cihazlardan gelen verilerin kağıt ve dosyalara geçirilmesiyle zorluklar ve yanlış kayıtlar ortaya çıkabilmektedir. Yoğun bakıma özgü bir yazılım sistemi, yoğun bakım hastalarının takip ve tedavisinde büyük avantajlar sağlamaktadır. Birimimizde kullanmakta olduğumuz yazılım sistemimizde nütrisyon rejimini belirlemek, enerji hedefine erişmek, olası yanlışları saptayarak düzeltmek, olumsuzluk yaratabilecek etkenleri azaltmak, doğru enerji değerlerine yaklaşmak ve malnütrisyon riskinden hastalarımızı uzak tutmak amacıyla farklı bir yaklaşımın gerekli olduğunu saptadık ve yoğun bakım yazılımı içinde ICNUS (Intensive Care Nutrition Software) adını verdiğimiz nütrisyon ile ilgili bir bölüm geliştirdik. Bu yazıda VKV Amerikan Hastanesi yoğun bakım ünitemizde 2 yıla yakın bir süredir kullanılmakta olan ICNUS' un özelliklerini ve kullanımıyla elde ettiğimiz avantajları yoğun bakımla uğraşanlarla paylaşmak istedik.

**Anahtar Sözcükler:** ICNUS yazılımı, nütrisyon, yoğun bakım

## Critically Ill Patients and Stress Response

Critically ill patients have complex treatment needs, often with multiple organs affected. Critically ill patients are a heterogeneous population, which includes patients with traumatic injuries (e.g. injuries to the skeletal system, brain, thorax, or abdomen) or burns, systemic infections, surgical complications (e.g. major blood loss or respiratory failure) and multiple organ failure. However, a common feature of the most critical illnesses is that they all give rise to severe metabolic stress, and many critically ill patients often develop systemic inflammation. In addition, they also have increased metabolic requirements; therefore, the need for a nutritional support must also be considered (1, 2).

In critically ill patients, the stress response directly influences neuroendocrine function. Changes in secretion of numerous hormones/neurotransmitters, such as acetylcholine, growth hormone and cortisol, combine to increase the body's basal metabolic rate, wherein substrates are mobilised to release energy sources (3-7). Hypercatabolism triggered by conditions of severe stress therefore increases the body's requirement for energy and protein. The increased metabolic requirements of critically ill patients are likely to accelerate the development of malnutrition, which must be considered when managing their treatment strategy (7).

Compared with healthy individuals, the protein turnover is increased and more often than not, dietary protein intake is considerably reduced. Under conditions of stress, body proteins are broken down rapidly, and urinary nitrogen excretion is increased beyond normal levels. Since amino acids released from the breakdown of protein in the muscles, bones and skin are used to support, in part, to increase synthesis of proteins involved in the stress response (e.g. immunoglobulins, acute

phase proteins, fibrinogen and albumin), at the whole-body level, a negative nitrogen balance occurs. Therefore, owing to catabolism in combination with a lack of physical activity and the hormonal milieu, critically ill patients may lose lean body mass (4, 8). An international observational study has shown that an additional 1000 Kcal nutrition provision results in an improved 60-day mortality and higher ventilator-free days (9).

Within the intensive care unit (ICU), patients with different pathologies have different protein requirements and elevated nitrogen excretion. Indirect calorimetry (IC) measurements have shown that the resting metabolic rate is also increased in patients who have undergone surgery, sustained trauma or burns, or with sepsis (10).

**Intensive Care Nutrition Software**

Nutritional support is provided along with intensive organ support modalities in intensive care patients. Our biggest asset in planning the therapy and support is careful observation of the patients. In the presence of severe, life-threatening problems, these observations often require usage of multiple equipment and devices simultaneously. To assess invasive

blood pressure monitoring, electrocardiography (ECG), pulse rate, central venous pressure, peripheral oxygen saturation (SpO<sub>2</sub>), end-tidal CO<sub>2</sub> partial pressure (P<sub>ET</sub>-CO<sub>2</sub>), body temperature, intracranial pressure/cerebral perfusion pressure, intra-abdominal pressure and urine output, we need devices, such as bedside monitors, respiratory mechanics measurements of the ventilators, metabolic monitors, pulse-wave analysis units, hemofiltration units and many from a broad spectrum.

The evaluation and analysis of multiple forms of data from this wide range of devices determines our approach in therapy and support. The process of transcribing and evaluating this data on paper by support staff, nurses and doctors in the ICU may be time consuming, particularly in patients with a significantly long length of stay.

The use of medical software specifically designed for ICU greatly improves the assessment of the data to enhance the quality of support and therapy for the patients and to reduce the workload of nurses and physicians. Most importantly, it facilitates to improve the management of time and workflow for the benefit of the patients.

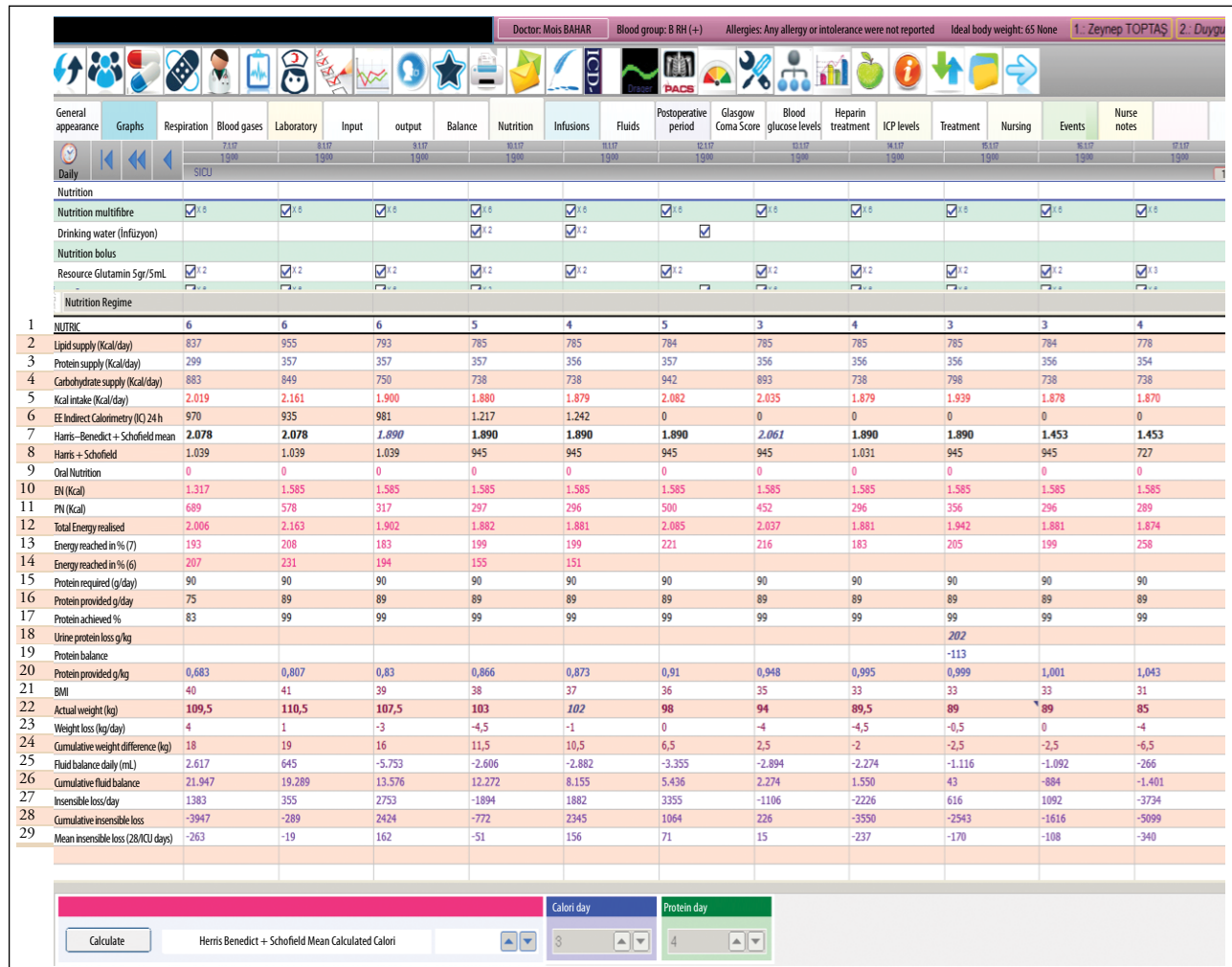


Figure 1. General view of the ICNUS screen on a daily basis

The bedside computerised information system (iMDsoft-Me-tavision) used in our ICU for almost 2 years has helped us ensure paper-free patient management. Every aspect of nutrition should be carefully observed to facilitate an efficient nutritional support. To determine the nutritional regime, to achieve the target of energy-level, to correct potential errors, to use Nutrition Risk in Critically Ill (NUTRIC) score (11) for reducing potential hazards and to assess the risk of malnutrition we concluded that a different approach was needed and thus developed and implemented Intensive Care Nutrition Software (ICNUS) with a new window on the screen (Figure 1).

The question was how to provide accurate information on energy/protein balance and to detect the risk of malnutrition and related complications at the earliest. ICNUS development was performed in a step-by-step manner. Within a time (minutes, hours and days) frame, we collected all caloric sources continuously, digitally checked for errors in data from our devices, corrected them and day by day enriched our experience with more precise and highly accurate nutritional measurements and evaluations. By using and developing ICNUS, we achieved our final goal where we could statistically analyse the complete stored nutritional status of all our patients.

Enteral Formulas			
	Amount	Times	
Osmolite / Glucerna	0 mL	0	0
Nutrision multi Fibre	0 mL	0	0
Nutrision GI Kontrol	0 mL	0	0
Isosource	0 mL	0	0
Jevit	0 mL	0	0
Nutrision Energy/Diben	0 mL	0	0
Nutrision Protein plus	0 mL	0	0
Impact Glutamin	0 mL	0	0
Isosource Energy	0 mL	0	0
Resourse	0 mL	0	0
Parenteral formulas			
Dipeptiven	4 mL	24	38,4
Kabiven Periferal	0 mL	0	0
Kabiven Santral	0 mL	0	0
Oliclinomel N4	0 mL	0	0
Oliclinomel N7	50 mL	24	1392
Smofcabiven Periferal	0 mL	0	0
Smofcabiven Santral	0 mL	0	0
Omegaven	4 mL	24	96

Calculate Total Amount = 1537,92 kcal/day Renew

Figure 2. Window for the planning of energy provision using caloric content of different nutrients

### Energy (Kcal) Requirements

The caloric requirements of an individual can be predicted mathematically using various formulae (12, 13); however, it is most accurately assessed by measuring oxygen consumption ( $VO_2$  mL  $min^{-1}$ ) and carbon dioxide production ( $VCO_2$  mL  $min^{-1}$ ) and subsequently analysed using the Weir formula to calculate the energy expenditure (14). With regard to patients in the ICU, 25–30 kcal  $kg^{-1}$  may be appropriate as the daily caloric requirement (15–17). An observational study showed that reaching clearly defined targets for energy and protein was associated with a decreased hazard ratio of death (18).

The caloric provision can be defined by evaluating the body mass index (BMI), whereby patients with a BMI of  $<25$   $kg\ m^{-2}$  and  $>35$   $kg\ m^{-2}$  can benefit from hypercaloric feeding and those with BMI from 25  $kg\ m^{-2}$  to  $<35$   $kg\ m^{-2}$  cannot benefit (16). The strategy used for the implementation of a nutritional support/therapy in our ICU for the critically ill is different regarding the mechanically ventilated and non-ventilated patients.

ICNUS initiates at 07.00 AM every day and collects the caloric need using the arithmetic mean of the Harris–Benedict + Schofield formulae. The follow-up of the daily caloric need is continuously shown on the screen in real time on a minute and hourly basis (Figure 1).

Enteral Formulas			
	Amount	Times	
About 24 gr substance, Resourse Glutamin substance,	0 gr	0	0
Protifar	0 Ölçek	0	0
Nutrision Multi Fibre			
Osmolite/Isosource	0 mL	0	0
Novasource GI Control			
Pedisure / Jevit			
Glucerna	0 mL	0	0
Nutrision Energy			
Nutrision Protein Plus	0 mL	0	0
Impact Glutamin			
Isosource Energy			
Parenteral formulas			
Dipeptiven	4 mL	24	19,2
Kabiven Periferal	0 mL	0	0
Oliclinomel N4	0 mL	0	0
Cabiven Cantral	0 mL	0	0
Smofcabiven Periferal			
Oliclinomel N7	50 mL	24	48
Smofcabiven	0 mL	0	0

Calculate Total Amount = 67,2 g/day Renew

Figure 3. Window for the planning of protein provision using protein content of different nutrients

1	NUTRIC	6	7	4	6	6	6	5	4	5	3	4	3
2	Lipid supply (Kcal/day)	121	345	837	955	793	785	785	784	785	785	785	784
3	Protein supply (Kcal/day)	63	175	299	357	357	357	356	357	356	356	356	356
4	Carbohydrate supply (Kcal/day)	397	784	883	849	750	738	738	942	893	738	798	738
5	Kcal intake (Kcal/day)	581	1.305	2.019	2.161	1.900	1.880	1.879	2.082	2.035	1.879	1.839	1.878
6	EE Indirect Calorimetry (KJ/24h)	1.987	1.948	1.933	1.931	1.898	2.092	2.560	2.681	0	0	0	0
7	Harris-Benedict + Schofield mean	2.267	2.078	2.078	2.078	2.078	1.890	1.890	1.890	1.890	2.061	1.890	1.890
8	Harris + Schofield	2.267	2.078	2.078	2.078	2.078	1.890	1.890	1.890	1.890	2.061	1.890	1.890
9	Oral Nutrition	0	0	0	0	0	0	0	0	0	0	0	0
10	EN (Kcal)	395	676	1.317	1.585	1.585	1.585	1.585	1.585	1.585	1.585	1.585	1.585
11	PN (Kcal)	184	591	689	578	317	297	296	500	452	296	356	296
12	Total Energy realised	579	1.267	2.006	2.163	1.902	1.882	1.881	2.085	2.037	1.881	1.942	1.881
13	Energy reached in % (7)	26	61	97	104	92	100	100	110	108	91	103	100
14	Energy reached in % (6)	29	65	104	112	100	90	73	78				
15	Protein required (g/day)	90	90	90	90	90	90	90	90	90	90	90	90
16	Protein provided g/day	16	44	75	89	89	89	89	89	89	89	89	89
17	Protein achieved %	18	49	83	99	99	99	99	99	99	99	99	99
18	Urine protein loss g/kg											202	-202
19	Protein balance											-113	
20	Protein provided g/kg	0,156	0,414	0,683	0,807	0,83	0,866	0,873	0,91	0,948	0,995	0,999	1,001
21	BMI	37	39	40	41	39	38	37	36	35	33	33	33
22	Actual weight (kg)	101,5	105,5	109,5	110,5	107,5	103	102	98	94	89,5	89	89
23	Weight loss (kg/day)	4,5	4	4	1	-3	-4,5	-1	-4	-4	-4,5	-0,5	0
24	Cumulative weight difference (kg)	10	14	18	19	16	11,5	10,5	6,5	2,5	-2	-2,5	-2,5
25	Fluid balance daily (ml)	6.267	4.508	2.617	645	-5.753	-2.606	-2.882	-3.355	-2.894	-2.274	-1.116	-1.092
26	Cumulative fluid balance	13.541	18.049	20.665	21.310	15.558	12.952	10.070	6.715	3.821	1.547	430	-662
27	Insensible loss/day	-1767	-508	1383	355	2753	-1894	1882	-645	-1106	-2226	616	1092
28	Cumulative insensible loss	-3541	-4049	-2665	-2310	442	-1452	430	-215	-1321	-3547	-2930	-1838
29	Mean insensible loss (28/ICU days)	-236	-270	-178	-154	29	-97	29	-14	-88	-236	-195	-123

Figure 4. Daily obtained nutritional data from ICNUS showing all the details of the patient's situation NUTRIC (1), Energy reached in % (14), protein reached % (17), BMI (21), cumulative weight difference (kg) (24), cumulative fluid balance (26), mean insensible loss (28/ICU days) (29)

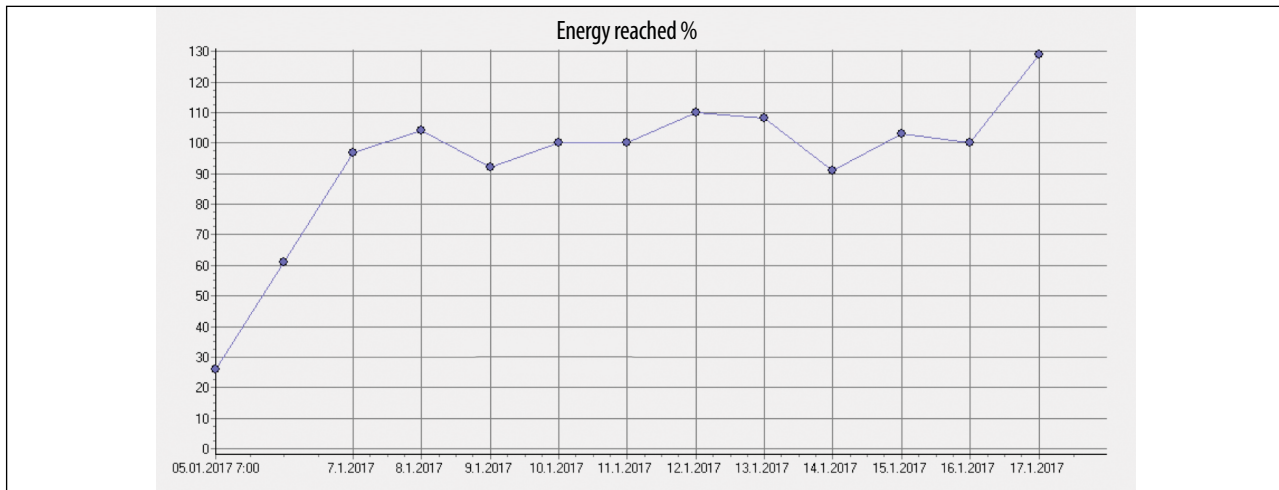


Figure 5. Graph showing in a period of time how the targeted energy is reached

There is no doubt that the best way to avoid underfeeding in ICU patients is to own and use an accurate tool: the IC device. The general approach must be to reach the energy needs and cover the energy target as close as possible (*Deltatrac II is no more produced by the Datex company but E-COVX is a new version of Deltatrac produced by the same company.*). In our ICU, the Engström Carestation ventilator is used; however, we have the opportunity to use the IC (E-COVX gas analysis module) and measure EE, VO<sub>2</sub>, VCO<sub>2</sub> and RQ continuously, and all the data are shown and collected in ICNUS within the same periods.

All EN and PN formulas used in the Turkish market were classified within their composition and uploaded to ICNUS as lipid, carbohydrate and protein energy (Kcal) and gram contents (Figures 2 and 3). The data of the fluids and nutrients administered are received from the infusion pumps (B Braun) directly and transferred to the software's nutrition window with each nutrient supply in Kcal and as per details required. If the patient is under mechanical ventilation, the EE is reflected via the IC, but the Harris-Benedict + Schofield (mean Kcal/2) equation values are calculated automatically to visualise the differences between each measurement (Figure 4). The nutritional therapy goal is followed with the

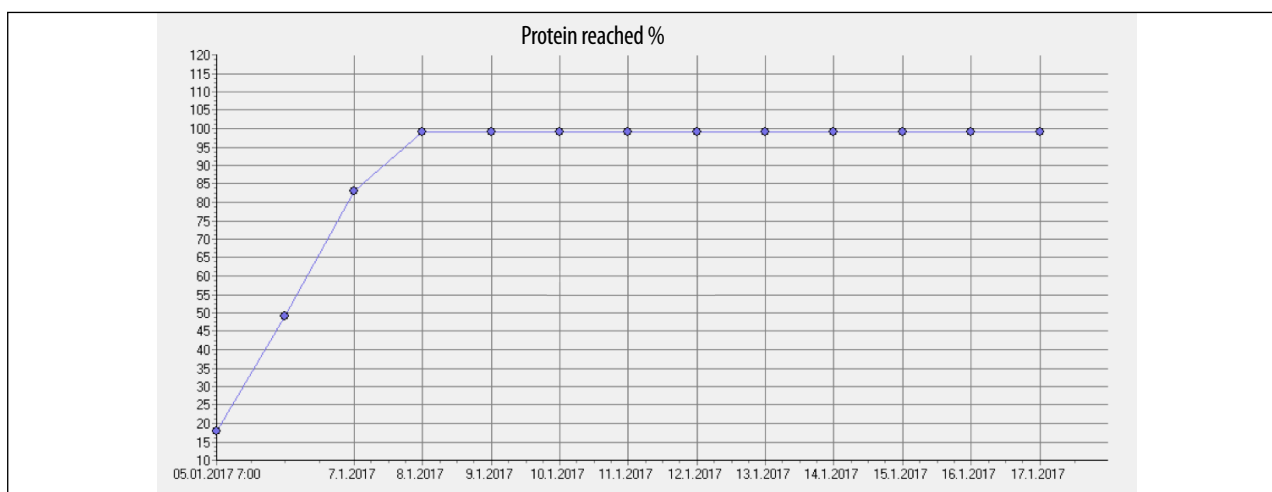


Figure 6. Graph showing in a period of time how the targeted protein provision is reached

System	Parameter	Value	Score
Respiration	Respiratory support	<input type="checkbox"/>	
	FI02	40 %	
Coagulation	PO2	115,7 mmHg	2
	Platelets	44 K/uL	3
Liver	PaO2/FiO2	289,25	
	Bilirubin	1,2 mg/dL	1
Cardiovascular	Dopamine	<input type="text"/> mcg/kg/min	
	Epinephrine	<input type="text"/> mcg/kg/min	
	Norepinephrine	0,05 mcg/kg/min	3
	Dobutamine	<input type="text"/> mcg/kg/min	
	MAP	<input type="text"/> mmHg	3
Central Nervous System	Eye response	Sözlü Uyan	
	Motor response	Emirleri Yerine Getiriyor	
	Verbal response	Konfüze/Dezoryante	13
Renal	Creatinine	1,8 mg/dL	1
	Urine	1995 mL	0
Total score			11

Figure 7. SOFA score calculation obtained from the ICNUS

calculated energy achieved in percentage as a ratio to the energy provided (Figure 5).

### Protein (g) Requirement

Protein requirements in critical illness are increased and ESPEN guidelines recommend an amount of 1.3–1.5 g/IBW. However, some situations, such as obese or oedematous conditions of the severely ill patients, give raise to over-feeding of protein. Therefore, the use of the BMI parameter seems to

avoid this situation. ICNUS calculates the protein requirement automatically using the actual body weight (ABW) for the adults using BMI between 20–30 kg m<sup>-2</sup> and the height for BMI <20 kg m<sup>-2</sup> and >30 kg m<sup>-2</sup> using the following equations (11, 17):

Adults:  $20 < \text{BMI} < 30 = 1,2 \times \text{ABW}$  (kg)

Adults:  $\text{BMI} < 20 = 24 \times \text{height}$  (m)<sup>2</sup>

Adults:  $\text{BMI} > 30 = 33 \times \text{height}$  (m)<sup>2</sup>

The protein provision is calculated automatically using ICNUS equivalent to the patient's nutritional requirement without any error, and during administration, the pumps data are observed continuously on the screen. The protein provision is followed with the calculated protein achieved in percentage as a ratio to the protein provided (Figures 4 and 6).

### Nutritional Risk in the Critically Ill Score

The NUTRIC risk assessment score (19) and other tools (20) can possibly identify critically ill patients who benefit the most from the nutritional therapy. Unfortunately, the majority of critically ill patients experience harm because they do not receive adequate nutritional intake (21).

ICNUS automatically calculates [without the IL-6 variable, which does not have a strong impact on the NUTRIC score (22)] the data for the NUTRIC scoring system on a daily basis together with APACHE II and SOFA scores and other related (age, number of comorbidities and ICU stay days) parameters in each patient (Figures 7-9). During the ICU stay, daily monitoring of NUTRIC scores gives us the chance to focus more on the provision of the adequate amounts of energy and protein for the calculated energy target when considering mortality as an outcome. ICNUS provides all the details for the accurate information on energy and protein provision and balance in critically ill patients and may allow for the early detection of malnutrition and its complications (Figures 4 and 10).



APACHE II | Patient admission datas

Variables

Temperature: 37,6 °C 0

Mean Arterial Pressure: 116 mmHg 2

HR: 135 beats/min 2

RR: 24 beats/min 0

Arterial PH: 7,46 0

HCO3: mEq/L

Serum Sodium: 137 mEq/L 0

Serum Potassium: 5 mEq/L 0

Serum Creatinine: 0,6 mg/dL 0

The patient has acute renal failure

Hematocrit: 33,6 % 0

WBC: 8,6 µmol/L 0

Oxygenation (A-aDO2 or PO2)

FiO2: 32

AaDO2: 118,1 mmHg

PaO2: mmHg

GCS

Eye response: spontaneous

Verbal response: Confuse

Motor: Obeying commands

Total GCS: 14 1

AaDO2

Intervals	Sadec...
< 200	0
>= 200 & < 350	2
>= 350 & < 500	3
>= 500	4

APACHE II score: 15 In-hospital mortality risk: 20,97 %

Figure 8. APACHE II calculation obtained from the ICNUS

Nutric

AGE 10.01.2017 07:04 (Kaydedildiği saat : 10.01.2017 10:04)

10.01.2017 07:04 Refresh

Nutric Skoru

AGE	72	Co-morbidities	2 and more
Apache II	20	IL-6	Not required !
Sofa	9		
Length of hospital stay (day)	5		

Calculate Nutric Score 6

Result: Worse outcome (mortality, ventilation)

Figure 9. NUTRIC score calculation obtained from the ICNUS

### Fluid Balance and Weight

One of the most important observations of the critically ill patients in the ICU is the close monitoring of fluid and electrolyte balance. The clear evidence of fluid administration is that it has life-saving intervention in severe hypovolemia, dehydration and septic shock. However, it can be detrimental and life-threatening when administered in high volumes, and we have to stress the importance that distribution within the body of critically ill patients is unpredictable due to glycocalyx injury and disturbances of lymphatic flow, fluids are leaving vascular bed and escape to the interstitium (23).

In such situations, changes of weight may arise and therefore errors in the calculations of the energy and protein requirements may be introduced (11). Macro-and micronutrients are administered with fluids, and many other infusions, such as antibiotics, inotropics, vasoactive drugs and electrolytes, given for other purposes are also added to the nutritional fluid amount. ICNUS realises with a high accuracy the fluid intake via the connection of the electronic infusion pumps (Braun), reflecting all the needs as fluid volumes entering the body classified as intravenous (IV) fluids, medications, PN and EN solutions and antibiotics (Figure 1).

Another important point is the patient's weight and the weight gain/loss during long stays in the ICU (Figures 11

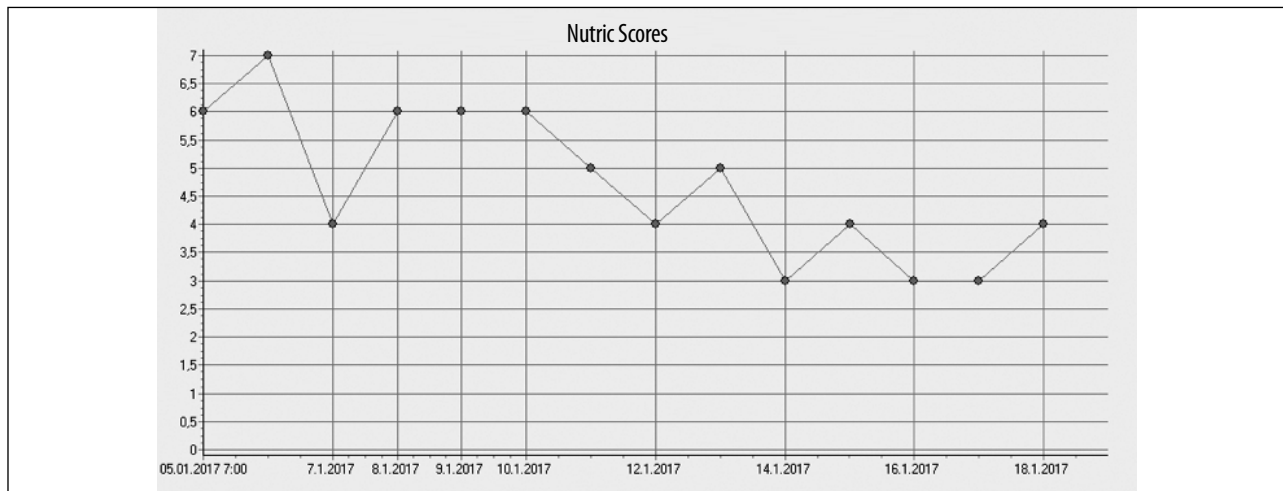


Figure 10. Graph showing in a period of time NUTRIC scores

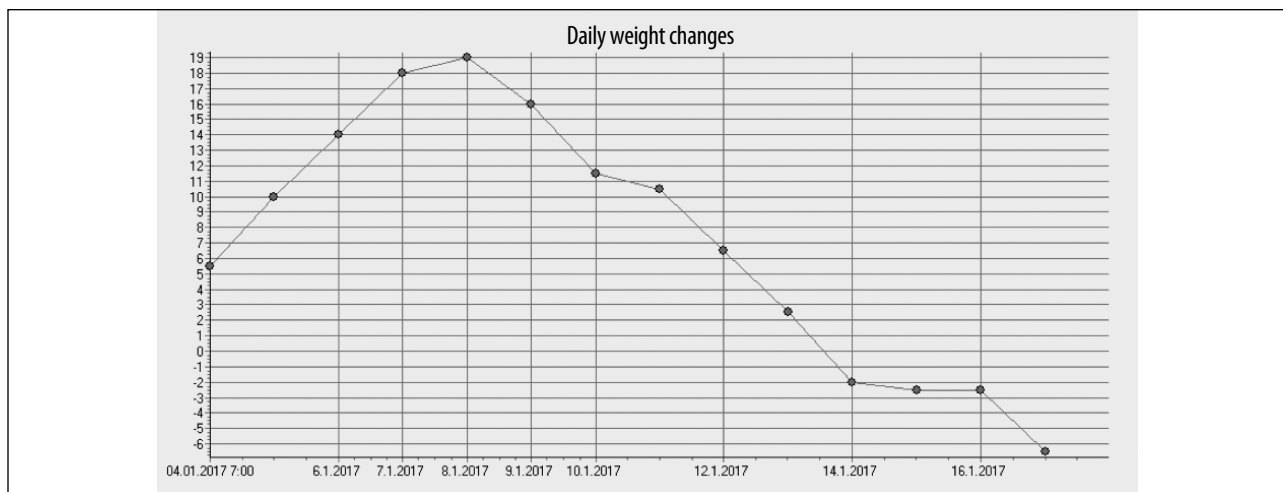


Figure 11. Graph showing in a period of time the weight changes daily

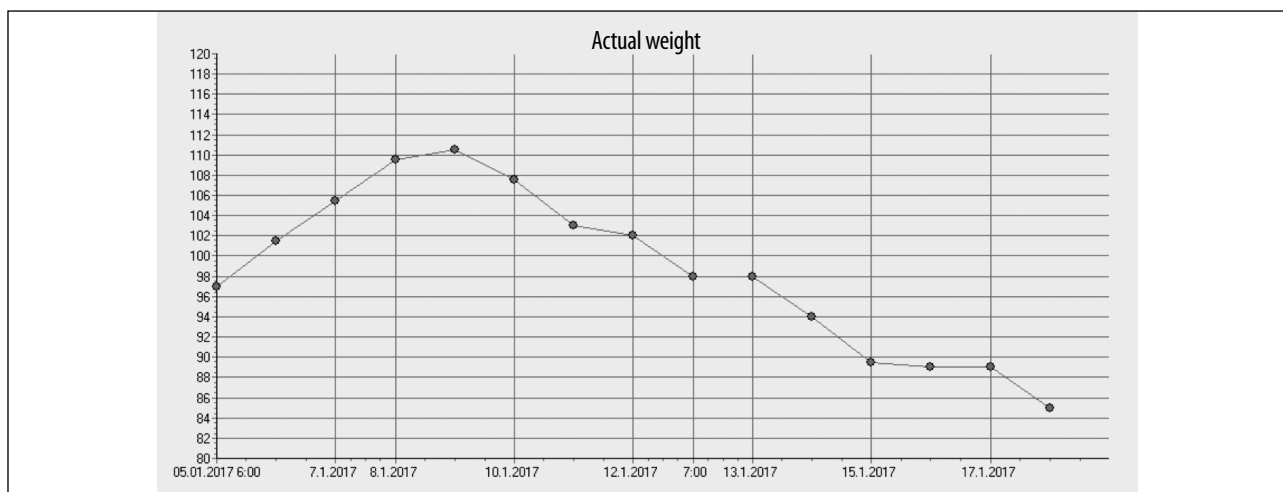


Figure 12. Graph showing in a period of time the daily cumulative weight gains and losses

and 12). In our unit, the patients are weighed every morning at 07.00 AM at the bedside (Hill-Rom ICU beds) and compared with the antecedent day's weight data. ICNUS can give

the opportunity to place the patient in a steady state with the collected precise data of nutritional therapy, body weight and fluid balance. When the patient is discharged from the unit

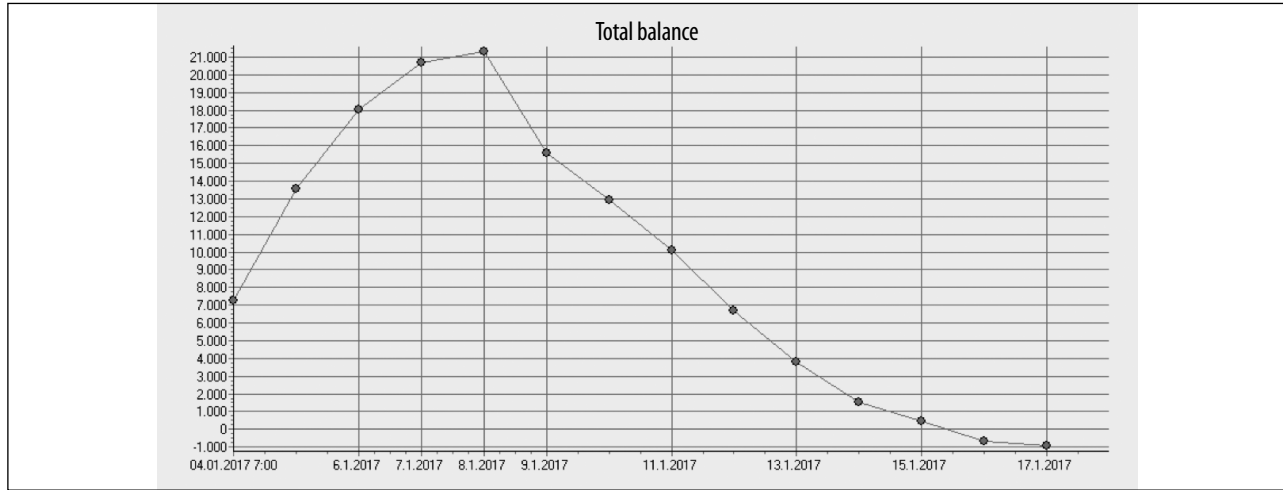


Figure 13. Graph showing in a period of time the daily cumulative fluid balance

we have an accurate overview of the weight during the ICU stay (Figures 4, 11 and 12).

One of our nutritional therapy goals is to follow the relationship between cumulative fluid and weight balance. Considering data from these two parameters, we can estimate the insensible loss at patient discharge (Figures 4, 12 and 13).

Experienced clinical nutritionists will aim to individualise therapy to the specific needs of their patients by considering the ICU conditions. But our experience has shown that in the majority of these patients, it seems impossible to achieve the targeted caloric and protein needs for the first 2–4 days, and negative energy and protein balance is inevitable (Figures 5 and 6).

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