

Decreased calorie and protein intake is a risk factor for infection and prolonged length of stay in surgical patients: A prospective cohort study

Diminuição da ingestão de calorias e proteínas é fator de risco para infecção e internação prolongada: estudo de coorte prospectivo

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ABSTRACT

Objective

The aim was to assess whether postoperative calorie and protein intakes increase the risk of infection and prolonged length of stay in a tertiary care university hospital in Southern Brazil.

Methods

This is a prospective cohort study approved by the hospital's Research Ethics Committee. The sample consisted of adult patients undergoing elective surgery. The exclusion criteria included patients who could not undergo nutritional assessment and those with a planned hospital stay of fewer than 72 hours. Nutritional status was assessed on admission and every seven days thereafter until hospital discharge or death. Demographic and clinical data, as well as information regarding independent and outcome variables, were collected from the patient's records. Food intake assessment was conducted by researchers six times a week. Calorie and protein

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intakes were considered adequate if equal to or greater than 75% of the prescribed amount, and length of stay was considered prolonged when above the average for specialty and type of surgery. Data was analyzed using Poisson regression.

Results

Of the 519 study patients, 16.2% had adequate nutritional therapy. Most of these patients were men with ischemic heart disease and acquired immunodeficiency syndrome. After adjusting for confounders, inadequate nutritional therapy increased risk of infection by 121.0% (RR=2.21; 95%CI=1.01-4.86) and risk of prolonged length of stay by 89.0% (RR=1.89; 95%CI=1.01-3.53).

Conclusion

Most patients did not have adequate nutritional therapy. Those with inadequate nutritional therapy had a higher risk of infection and longer length of stay.

Keywords: Infection. Length of stay. Nutrition therapy. Surgery. Patients.

RESUMO

Objetivo

Avaliar se a quantidade de calorias e proteínas ingeridas no pós-operatório aumenta o risco de infecção e de permanência hospitalar prolongada, em um hospital universitário no Sul do Brasil.

Métodos

Estudo de coorte prospectivo, aprovado por Comitê de Ética e Pesquisa. A amostra consistiu de adultos hospitalizados submetidos à cirurgia eletiva. Os critérios de exclusão foram pacientes que não tinham condições para avaliação do estado nutricional e aqueles com menos de 72 horas de hospitalização. O estado nutricional foi avaliado na admissão e a cada sete dias até a alta hospitalar ou óbito. Dados clínicos, demográficos, informações sobre as variáveis independentes e os desfechos, foram coletados dos prontuários. Avaliação da ingestão alimentar foi conduzida pelos pesquisadores seis vezes por semana. A quantidade de calorias e proteínas ingeridas foi considerada adequada se igual ou maior que 75% da quantidade prescrita, e permanência hospitalar foi considerada prolongada quando acima da média de acordo com a especialidade e tipo de cirurgia. Os dados foram analisados por meio de regressão de Poisson.

Resultados

De 519 pacientes avaliados, 16,2% tiveram adequada terapia nutricional. A maioria destes pacientes eram masculinos com doença cardíaca isquêmica e síndrome da imunodeficiência adquirida. Após ajuste para variáveis de confusão, inadequada terapia nutricional aumentou o risco de infecção em 121,0% (RR=2,21; IC95%=1,01-4,86) e o de permanência hospitalar prolongada em 89,0% (RR=1,89; IC95%=1,01-3,53).

Conclusão

A maioria dos pacientes não recebeu terapia nutricional adequada, aqueles sob inadequada terapia nutricional tiveram aumento do risco de infecção e permanência hospitalar prolongada.

Palavras-chave: Infecção. Tempo de internação. Terapia nutricional. Cirurgia. Pacientes.

INTRODUCTION

Malnutrition can be defined as a “cellular imbalance between the supply of nutrients and energy and the body’s demand for them to ensure growth, maintenance, and specific functions”¹ (p.157). The prevalence of malnutrition is high in the hospital setting, with rates sometimes estimated to be as high as 50% in hospitalized adults².

Nutritional depletion in hospitalized patients can be caused by the combination of many different factors, such as the underlying disease, comorbidities, intake difficulties, medication side effects, physical inactivity^{3,4}, and health care workers’ lack of focus on nutritional therapy^{5,6}.

One of the most important factors in the etiology of malnutrition is suboptimal food intake

during hospital stay⁷. Although adequate food intake is essential for the clinical management of malnutrition, Kowanko *et al.*⁸ found that over one-third of patients in intensive care consume less than 50% of the calories provided by the standard hospital diet. In a recent study, Bauer *et al.*⁹ also found that approximately 50% of patients reported eating half or less of their meals, and these patients were four times more likely to be malnourished than patients who ate more than half of the meals.

Some possible consequences of hospital malnutrition are prolonged hospital stays, increased mortality rates, and an increased risk of complications, such as hospital infections, falls, and wound healing problems^{1,10}.

Although nutritional therapy is essential for the effective treatment of malnourished patients¹¹. Hiesmayr *et al.*¹² studied a European population and found that low food intake was an independent risk factor for mortality. However, this was a one-day cross-sectional study, and it did not assess long term outcomes.

Despite the fact that the aforementioned studies demonstrate the negative effects of low food intake and the importance of early postoperative nutritional interventions, in our setting this practice still seems uncommon.

Given the importance of nutritional therapy in treating hospital malnutrition, the present study aimed to assess, in a tertiary care university hospital in Southern Brazil, the postoperative calorie and protein intakes of elective surgery patients and whether intake affects the risk of infection and prolonged hospital stay.

METHODS

An observational prospective cohort study was conducted in a tertiary university hospital. Written Informed Consent was provided by each participant, and the study was approved by the hospital's Research Ethics Committee under Protocol number 110307.

Patients undergoing elective digestive, general, proctologic, thoracic, urological, and vascular surgery were recruited between August 1st, 2011 and October 25th, 2012 from the *Hospital de Clínicas de Porto Alegre*, in the state of *Rio Grande do Sul* in Southern Brazil. Eligible patients were identified through the hospital's electronic database. The patients who could not undergo nutritional assessment were excluded, as well as those admitted to the regular surgical unit, those with a planned hospital stay of fewer than 72 hours, and those admitted for tests. Participants were recruited by convenience sampling (according to the availability of the research during the research period). Nutritional status and adherence to nutritional therapy were not assessed in patients transferred to the intensive care unit after inclusion in the study, but upon leaving the intensive care unit, patients were followed-up and assessed until hospital discharge.

Data was collected from digital patient records from *Hospital de Clínicas de Porto Alegre*. Demographic and clinical data, as well as information related to the variables of interest and patient outcomes were prospectively collected starting at hospital admission or up to 48 hours before surgery, until hospital discharge or death. Data regarding clinical characteristics, surgical complications, and hospital infection were collected daily from physical and digital patient records. The trained researchers who conducted the present study assessed the patients' food intake by nutritional interviews. Nutritional interviews during the hospital stay were conducted daily, from Monday to Friday, except for holidays. Patients answered the questions by themselves or aided by the researcher. The interview consisted of standardized questions formulated for the study on the patients' food intake on the previous day, percentage of hospital meal intake (less than 25%, 25%, 50%, 75%, or 100%). Data about the enteral and parenteral diet (when applicable) prescribed for each patient were obtained from physical and digital patient records.

After inclusion in the study, patients underwent anthropometry, including measurements of height, weight, mid-upper arm and calf circumferences, triceps skinfold thickness, and bioelectrical impedance analysis to assess body composition (fat and lean mass). Nutritional status was classified according to the World Health Organization's criteria for body mass index, which involves a different categorization system for adult and elderly patients (over 60 years of age) and to the subjective global assessment. This assessment protocol was repeated every 7 days, after inclusion.

Endpoint infection was collected from notes by the Infection Control Committee in the electronic system. The endpoint prolonged length of stay was the duration (in days) of hospital stay, and prolonged was defined as a stay longer than the 2010 mean or median stay (the year preceding the study), by type and extent of surgery, as well as the underlying disease that led to the surgery in each study specialty.

The study exposure variable of interest was the nutritional therapy received by the patients in terms of calorie and protein content. Intake was considered adequate when the patient consumed at least 75% of the calories and proteins prescribed. Covariates consisted of age, subjective nutritional assessment, body mass index on hospital admission, surgery extent, surgery contamination risk, postoperative complications, and cancer.

The statistical analysis was done by PASW (SPSS Inc., Quarry Bay, Hong Kong, China) version 18. Continuous variables with normal distribution were expressed as mean \pm Standard Deviation (SD), and categorical data were expressed as absolute figures or percentages. Comparison between the groups was done by the Chi-square test for categorical variables, and the Student's *t* test for continuous variables. Poisson regression with robust variance and binary outcome was used to calculate the relative risk, adjusted for confounders. The variables in the Poisson regression were selected from univariate analysis,

considering $p < 0.20$. This model included the variables: age, gender, comorbidities, nutritional status, type of anesthesia, potential surgical contamination, ASA score (American Society of Anesthesiologists, Schaumburg, Illinois, United States), duration of surgery, intensive care unit stay, and postoperative complications.

RESULTS

A total of 1,074 potentially eligible patients were identified for the study. Of these, 383 did not meet the eligibility criteria because they had pacemakers ($n=30$) (could not undergo bioelectrical impedance analysis), underwent gastroplasty ($n=48$), and were directly admitted into the surgical intensive care unit ($n=257$), among other reasons ($n=48$). A total of 691 patients were included in the study, and since 170 did not undergo surgery and 2 could not undergo dietary assessment, the final sample consisted of 519 patients. Excluded patients ($n=555$) had shorter schooling ($p < 0.001$) than included patients, but there was no significant difference between the other baseline demographic and clinical characteristics (data not shown).

Clinical and demographic characteristics of the final sample ($n=519$) are displayed in Table 1. Patients who had adequate calorie intake were mostly male and had a higher percentage of ischemic heart disease and acquired immunodeficiency syndrome. Nutritional status, type of surgery, intensive care unit stay, and postoperative complications did not differ significantly by group.

Most patients received oral feeding, while 10.4% received enteral nutrition, 6.0% received both oral and enteral nutrition, and 0.8% received parenteral nutrition. Excluding patients who received parenteral nutrition, out of the 519 patients assessed, the mean calorie and protein intakes prescribed and consumed were higher in patients who received adequate nutritional therapy (consumed more than 75.0% of the amount prescribed) (Table 2).

Table 1. Clinical and demographic sample characteristics. *Porto Alegre (RS), Brazil, 2013.*

Variables	Total sample (n=519)		Consumed more than 75% of the diet prescribed		p
			Yes (n=84)	No (n=435)	
Age, years	60.0 ± 13.0		60.1 ± 12.0	60.0 ± 13.0	0.95
Sex (male)	323	(62.2)	65 (77.4)	252 (59.3)	0.002
<i>Education (years of schooling)</i>					0.80
None	41	(7.9)	7 (8.3)	34 (7.8)	
Less than 8 years	378	(72.8)	63 (75.0)	315 (72.4)	
More than 8 years	100	(19.3)	14 (16.7)	86 (19.8)	
<i>Clinical Comorbidities</i>					
Cancer	315	(60.7)	49 (58.3)	266 (61.1)	0.62
Diabetes	72	(13.9)	9 (10.7)	63 (14.5)	0.36
Ischemic Heart Disease	30	(5.8)	10 (11.9)	20 (4.6)	0.009
COPD	19	(3.7)	3 (3.6)	16 (3.7)	0.96
Heart Failure	11	(2.1)	2 (2.4)	9 (2.1)	0.85
Renal disease	10	(1.9)	-	10 (2.3)	0.16
AIDS	9	(1.7)	5 (6.0)	4 (0.9)	0.001
<i>Body mass index</i>					0.93
Underweight	22	(4.2)	3 (3.6)	19 (4.4)	
Normal weight	209	(40.3)	32 (38.1)	177 (40.7)	
Overweight	181	(34.9)	30 (35.7)	151 (34.7)	
Obese	107	(20.6)	19 (22.6)	88 (20.2)	
<i>Subjective Global Assessment</i>					0.72
Well nourished	445	(85.9)	74 (88.1)	371 (85.5)	
Moderately malnourished	56	(10.8)	7 (8.3)	49 (11.3)	
Severely malnourished	17	(3.3)	3 (3.6)	14 (3.2)	
Weight (kg)	73.6 ± 15.4		74.5 ± 14.9	73.5 ± 15.5	0.58
Lean mass (kg)	48.5 ± 12.8		49.7 ± 12.6	48.3 ± 12.9	0.35
<i>Type of surgery</i>					0.08
Urologic	187	(36.0)	39 (46.4)	148 (34.0)	
Digestive	104	(20.0)	12 (14.3)	92 (21.1)	
Proctologic	81	(15.6)	10 (11.9)	71 (16.3)	
General surgery	46	(8.9)	3 (3.6)	43 (9.9)	
Thoracic	36	(6.9)	7 (8.3)	29 (6.7)	
Other	65	(12.5)	13 (15.5)	52 (12.0)	
ICU admission	46	(8.9)	5 (6.0)	41 (9.4)	0.30
Postoperative complications	104	(20.0)	16 (19.0)	88 (20.2)	0.80

Note: Values presented as mean ± standard deviation or number and percentage.

COPD: Chronic Obstructive Pulmonary Disease; AIDS: Acquired Immunodeficiency Syndrome; ICU: Intensive Care Unit.

Table 2. Calories and proteins prescribed and consumed by patients who did and did not receive adequate nutritional therapy. *Porto Alegre (RS), Brazil, 2013.*

Calories and proteins	Adequate nutritional therapy						p
	Total sample (n=519)		Yes (n=84)		No (n=435)		
	M	SD	M	SD	M	SD	
Calories prescribed/day	1,603.0	122.0	1,698.0	472.0	1,525.0	117.0	0.010
Calories intake/day	1,057.0	406.0	1,476.0	104.0	708.0	180.0	<0.001
Protein prescribed (g/day)	64.3	21.0	70.0	14.0	59.5	22.0	<0.001
Protein intake (g/day)	40.0	16.2	57.0	19.0	26.3	19.0	<0.001

Note: M: Média; SD: Standard Deviation.

Calorie and protein intakes and their association with infection and prolonged length of stay

Univariate analysis (Table 3) suggested that the risk of infection was higher in patients who consumed less than 75.0% of the calories and proteins prescribed (RR=2.15; 95%CI=0.88-5.20), underwent major surgery (RR=3.25; 95%CI=1.79-5.91), were contaminated during surgery (RR=3.57; 95%CI=1.82-6.99), were malnourished (RR=2.39; 95%CI=1.21-4.72), had cancer (RR=1.55; 95%CI=1.02-2.38), or presented postoperative complications (RR=4.19; 95%CI=2.93-6.0). Univariate analysis also found that the risk of prolonged length of stay (Table 4) was higher in patients who underwent major surgery (RR=1.63; 95%CI=1.16-2.30), were contaminated during surgery (RR=1.14; 95%CI=0.60-2.14), had diabetes (RR=1.49; 95%CI=1.06-2.09), had chronic obstructive pulmonary disease (RR=1.81; 95%CI=1.10-2.98), and presented postoperative complications (RR=2.15; 95%CI=1.64-2.83). Moreover, patients who consumed less than

75.0% of the calories and proteins prescribed (RR=1.71; 95%CI=0.89-3.25) also had a higher risk of prolonged length of stay.

Multivariate analysis showed that the consumption of less than 75.0% of the prescribed calories and proteins led to an increased risk of infection of 121.0% (RR=2.21; 95%CI=1.01-4.86) (Figure 1A). Multivariate analysis also found that major surgery (RR=1.35; 95%CI=0.58-3.10), medium-sized surgery (RR=1.44; 95%CI=0.66-3.14), potentially contaminated surgery (RR=2.31; 95%CI=1.15-4.65), and postoperative complications (RR=2.98; 95%CI=1.70-5.23) significantly increased the risk of infection (Figure 1A).

Multivariate analysis showed that consuming less than 75.0% of the prescribed calories and proteins was a risk factor for prolonged length of stay, increasing the risk of prolonged stay by 89.0% (RR=1.89; 95%CI=1.01-3.53) (Figure 1B). Multivariate analysis also showed that patients who underwent major surgery and had postoperative complications had 12.0%

Table 3. Infection risk in patients grouped by clinical features. *Porto Alegre* (RS), Brazil, 2013.

Features	Incidence of infection (%)		RR (95%CI)
	Feature present	Feature absent	
Cal. and Prot. intake <75%	24.4	10.7	2.15 (0.88-5.20)
Major surgery	28.3	14.3	3.25 (1.79-5.91)
Old age	19.3	13.7	1.49 (0.94-2.10)
Cancer	19.7	12.6	1.55 (1.02-2.38)
Malnutrition	35.3	14.8	2.39 (1.21-4.72)
Contaminated surgery	30.0	8.4	3.57 (1.82-6.99)
Postoperative complications	43.7	10.3	4.19 (2.93-6.00)

Note: Cal: Calories; Prot: Protein.

Table 4. Prolonged hospital stay risk in patients grouped by clinical features. *Porto Alegre* (RS), Brazil, 2013.

Features	Prolonged length of stay (%)		RR (95%CI)
	Feature present	Feature absent	
Cal. and Prot. intake <75%	34.5	21.4	1.71 (0.89-3.25)
Major surgery	41.4	25.4	1.63 (1.16-2.30)
Diabetes	37.5	25.2	1.49 (1.06-2.09)
COPD	47.4	26.1	1.81 (1.10-2.98)
Contaminated surgery	31.3	23.4	1.14 (0.60-2.14)
Postoperative complications	47.6	21.8	2.15 (1.64-2.83)

Note: Cal: Calories; Prot: Protein; COPD: Chronic Obstructive Pulmonary Disease.

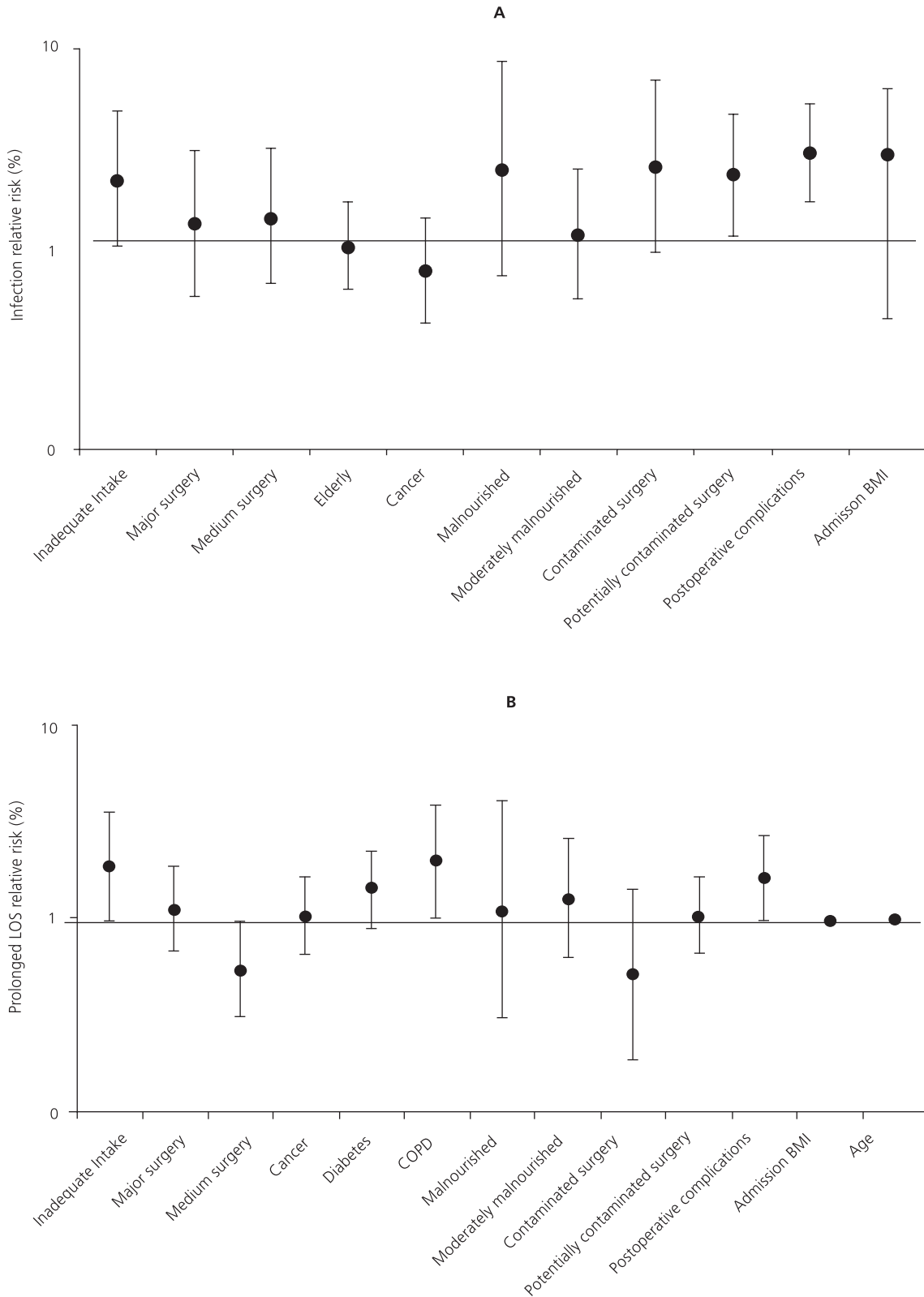


Figure 1. Adjusted relative risk for the outcomes infection (A) and prolonged length of stay (B). *Porto Alegre (RS), Brazil, 2013.*

Note: BMI: Body Mass Index; COPD: Chronic Obstructive Pulmonary Disease; LOS: Length of Stay.

(95%CI=0.66-1.88) and 61.5% (95%CI=0.98-2.65) higher risks of prolonged length of stay, respectively, than patients not exposed to these factors (Figure 1B).

DISCUSSION

The present prospective cohort study aimed to analyze the nutritional therapy offered to patients hospitalized for elective surgery, and to assess whether low calorie and protein intakes during stay, among other factors, is associated with a higher risk of specific hospital-related outcomes. Most (83.3%) patients in the study consumed less than 75.0% of the prescribed calories and proteins, and only 16.2% had adequate calorie-protein intake. A retrospective study¹³ found that only 25.0% of the patients consumed enough calories and proteins by the fourth day of stay. In a 10-year comparative prospective study of hospitals in Switzerland, the authors found that the proportion of undernourished patients remained unchanged (69.0 *versus* 70.0%) after the implementation of a nutritional program¹⁴.

The mean calorie and protein intakes by patients with inadequate nutritional therapy were less than half (48%) the prescribed amount. Similar results were found by Hiesmayr *et al.*¹², who reported that 64% (n=3673) of patients consumed less than half of their meals, and by the Nutrition Care Day study⁷, which found that 90% of patients consumed \leq 50% of their meals.

Patients with inadequate calorie-protein intake (less than 75% of the prescribed amount) had an increased risk of certain unfavorable outcomes, such as a 121% increase in infection risk and an 89% increase in the risk of prolonged length of stay, after adjusting for confounders. Hiesmayr *et al.*¹² also found that low food intake was an independent risk factor for mortality during stay. On the other hand, high calorie and protein intakes led to improved quality of life in a randomized study comparing two groups of patients at nutritional risk¹⁵.

The rate of infection in surgery patients at a university hospital was estimated to be 6.0%

by Medeiros *et al.*¹⁶. However, the infection rate found by the present study (22.1%) was similar to that reported (23.6%) by Villas Boas & Ruiz¹⁷. Additionally, the risk of infection was 35% higher in the study patients who underwent major surgery. A Brazilian study¹⁸ has found that improved pain control and reduced surgical trauma contribute to reduce length of stay after major thoracic surgery, and, in agreement with the present findings, suggested that the risk of prolonged stay after major surgery was 12.0% higher than after other types of surgery. Other studies have also suggested that the risk of prolonged stay is 3.1 times higher in patients with postoperative complications (fistula, evisceration, and surgical wound dehiscence)^{19,20}.

Some authors^{21,22} have also found associations between malnutrition, moderate or severe nutritional risk, and prolonged length of stay or infection. This finding is consonant with the present study. In univariate analysis, malnourished patients according to the subjective global assessment had a higher risk of infection.

Oral food intake is more physiological, respects the normal transit of nutrients through the gastrointestinal tract, presents fewer complications, and has lower costs than enteral or parenteral feeding²³. Nevertheless, low calorie and protein intakes were observed regardless of the route of feeding. These results were corroborated by other studies²⁴ which found that enteral feeding does not ensure adequate calorie intake, especially in patients undergoing intensive therapy²⁵. Parenteral nutrition may be better able to meet caloric requirements²⁶, but this could not be verified by the present study as few patients (0.8%) received such feeding.

The taste of hospital food, limited meal choices, and meals served too early were some of the reasons cited by patients for the low calorie and protein intakes during stay. Disease or treatment factors did not appear to influence calorie intake²⁷. The present study did not aim to assess the causes of low food intake, as there is significant variability in the duration of pre- and postoperative fasting between surgical specialties.

Furthermore, recent practices such as shorter fasts and preoperative dietary counseling^{28,29} have not yet been implemented by the Brazilian health system. Studies of the Enhanced Recovery After Surgery pathway show that these practices can help to reduce hospital lengths of stay after abdominal surgery by as much as 25% with no adverse effects³⁰.

The prospective study design ensured collection of independent and outcome variables. While convenience sampling may have led to selection bias, the inclusion of patients in different stages of disease and treatment may have led to a representative assessment of patients undergoing surgery in the study hospital. Factors that may have led to underestimated calorie and protein intakes, such as consumption of different diets and non-hospital food, can be considered study limitations, as well as the fact that nutritional therapy was considered adequate when calorie and protein intakes were at least 75% of the prescribed amount, since other studies generally consider nutritional requirements and total energy expenditure²⁷.

CONCLUSION

Most patients did not have adequate calorie and protein intakes; those with inadequate nutritional therapy had an increased risk of infection and were more likely to have prolonged length of hospital stays. By successfully assessing the effects of hospital nutritional therapy on hospitalization outcome, the present study found that adequate nutritional therapy (consumption of >75% of prescribed nutrients) protects against infection and prolonged length of hospital stays. These findings suggest that efforts must be made to ensure that patients receive and consume sufficient calories and proteins during stay.

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CONTRIBUTORS

MCS ASSIS carried out the study; made substantial contributions to study conception and design, and data acquisition, analysis, and interpretation; drafted the paper and revised it for important intellectual content; and approved the final version for publication. CRM SILVEIRA helped to draft the manuscript and collect data. MG BEGHETTO made substantial contributions to study conception and design, and data analysis and interpretation. ED MELLO conceived the study; participated in its design and coordination; and helped to draft the manuscript. All authors read and approved the final manuscript.

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