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Relations between undernutrition and nosocomial infections in elderly patients

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Abstract

Background: hospital-acquired infections and malnutrition are of major concern in public health in elderly patients. However, the interactions between these two entities are not well established.
Objectives: to determine the incidence of nosocomial infections (NI) and its association with malnutrition.
Subjects: 185 hospitalised older adults aged 81.6 ± 0.6 years old were nutritionally assessed on admission by measurement of anthropometric variables, serum nutritional proteins and evaluation of dietary intake. During hospitalisation, patients' progress was closely monitored, particularly for the detection of nosocomial infections.
Results: the incidence rate of NI was 59% and the global infection rate was 7.6/1000 bed days. The most common infection site was the urinary tract ($n=63$). The nutritional status of the population was studied by comparing three groups defined according to the absence (group I, $n=116$), presence of one infection (group II, $n=38$) or presence of more than one infection (group III, $n=31$). All but one anthropometric parameters varied among the three groups. Total energy intake also varied among the three groups. The group I had higher daily nutrient intake than the other two groups (respectively $P=0.004$ and $P<0.0001$). Albumin, transthyretin, and C-reactive protein levels differed significantly among the three groups (respectively $P<0.0001$, $P<0.0001$ and $P=0.0003$). Age, energy intake, length of hospital stay and the presence of a urinary catheter were independent risk factors of nosocomial infection.
Conclusion: our findings show that patients with multiple NI were older, showed an altered nutritional status, a prolonged recovery, more frequently had urinary catheters and more discharge placement.

Keywords: *malnutrition, nosocomial infection, elderly*

Introduction

Hospital-acquired infections are of major concern in public health. They are a frequent complication of hospitalisation and are associated with high morbidity, mortality rate and costs [1, 2]. Malnutrition is known to impair immune function, particularly cell-mediated immunity [3, 4]. Several studies have reported infections as a complication of malnutrition in different populations of patients, mainly in surgical units [5–10]. Less attention has been paid to elderly

hospitalised patients. Malnutrition is often seen in elderly people; 30–60% of geriatric patients in intermediate- or long-stay wards are malnourished. Thus, those patients may particularly be at risk of developing a nosocomial infection. Data from the National Nosocomial Infections Survey have shown that 54% of all nosocomial infections occurred in people aged 65 and older [11]. The urinary tract and lung are the most commonly encountered sites of hospital-acquired infection. Risk factors for nosocomial infections depend on the infection's site and care settings. Mechanical ventilation and indwelling urinary catheter are the most important risk factors of nosocomial pneumonia and urinary infection, respectively. A number of other risk factors have been identified in older patients, including neurological diseases, respiratory diseases, diabetes mellitus, decreased consciousness, deteriorating health, disorientation, difficulty with swallowing, aspiration, nasogastric tube, inhalation therapy, increased agitation, dependency, central vascular or peripheral line, incontinence, previous antibiotic therapy, history of nosocomial infection and sedation medication [12–14]. Moreover, some studies have evaluated malnutrition as a possible risk factor for nosocomial infections in those patients [7, 12–16] but the results were not convincing. However, those studies differed in terms of criteria used to evaluate nutritional status and in terms of populations selected.

Therefore, this prospective study was designed to determine the global infection rate of nosocomial infection in elderly in-patients and to evaluate its association with the nutritional status assessed by anthropometric and biological measurements.

Methods

Patients

One hundred and eighty-five patients aged 70 years or older (45 males and 140 females, mean age 81.6 (SEM 0.6) years), consecutively admitted to the Albert Chenevier Hospital (Creteil) between January 2002 and July 2004 were enrolled. These patients had been transferred from acute medical (62) or surgical (123) units of other hospitals, to the geriatric rehabilitation unit of our department of Internal Medicine. The most frequent medical diagnoses were pulmonary disease, congestive heart failure and cerebral vascular accident. Surgery was most often due to hip fracture or hip prosthesis. A multidisciplinary geriatric team provided care for patients in this unit: the unit geriatrician, two medical fellows, rehabilitation nurses, physical therapists and a social worker. Patients included in this study were medically stable at admission and required long term care and rehabilitation. Near terminal medical disorders (e.g. advanced malignancy, decreased consciousness, advanced dementia) precluded participation in the study. Patients were also excluded from the study if their stay in the rehabilitation unit was shorter than 72 hours. The main criterion for hospital discharge was the recovery of walking self-sufficiency. Patients were informed of the purpose of the study in writing and gave their oral consent. The study design and procedures were in accordance with the recommendation of the hospital ethics committee.

Study design

A standardised questionnaire was used on admission to our unit (Day 0) for recording age, gender, detailed information on past medical history, drug therapy, cognitive status using respectively the Mini-Mental State (MMS) of Folstein *et al.* [17]. Patients were nutritionally assessed on Day 0 by measurement of anthropometric variables and evaluation of dietary intake. A blood sample was collected after an overnight fast on the same day as the nutritional assessment for determination of serum proteins.In addition, during their stay in hospital, patients' progress was closely monitored, particularly for the detection of nosocomial infections until discharge from the geriatric unit or death.

Anthropometric measurements

Body weight, height and body mass index (BMI) (weight/height^2) were recorded. Mid-arm circumference (MAC), triceps and biceps skinfold thickness (TST and BST) were measured. Skinfold thicknesses were measured by the same operator to the nearest mm using a Harpenden Caliper and the average of three consecutive measurements was calculated.

Dietary intake

The patients received the usual diet given in hospitals of the Assistance Publique-Hopitaux de Paris, supplying on average 2,200 kcal/day with the proportions of carbohydrate, lipid and protein respectively of 55, 30 and 15% energy. The diet was conventional, nutrients and fluids were given orally. Extra servings, beverages, and snacks were systematically proposed. The same dietitian recorded the energy and protein intakes immediately after each meal by estimation of portion sizes. Oral supplements were also recorded with the help of the ward nurses. Data acquisition was made in grams and daily nutritional consumption was quantified by the CIQUAL data base from Mac 2 Win software 1990–2000 (Altura Software Inc.). Data are given as 3-day food record.

Assessment of nosocomial infection

The incidence of nosocomial infection was determined by one investigator who visited each hospitalised patient and reviewed the medical records with a referring physician and the nurse of the unit. Nosocomial infection was defined as a well-documented infection absent on admission and surgical-site infection and occurring in the 30 days following surgery. The definitions of nosocomial infection from the Center for Disease Control or from Inter-Clin (Comités de Lutte contre les Infections Nosocomiales) gériatrique de l'Assistance Publique-Hôpitaux de Paris [18, 19] were fulfilled in each case. In order to detect nosocomial infection, the investigator collected various combinations of clinical findings (fever, rales or dullness, dyspnoea, cough, purulent sputum, dysuria, frequent bladder urgency, suprapubic tenderness, clinical sepsis, purulent drainage from surgical incision) and results of laboratory (blood culture, urine culture, isolation of pathogen from other specimens, antigen- or antibody detection tests) and other diagnostic tests (X ray studies, computed tomography scan).

Only those nosocomial infections with microbiology and/or radiological confirmation were taken into account.

Biological measurements

Serum C-reactive protein (CRP), orosomucoid and transthyretin concentrations were analysed immunoturbidimetrically on a Synchron CX5 analyzer (Beckman-Coulter, Roissy, France). Serum albumin was measured by means of the bromocresol green method on the same analyser.

Statistical analysis

Analysis of the data was performed with Statview statistical software package, version 5.0 (SAS Institute Inc.). The results were expressed as means with their standard errors. Three groups were compared by one-way ANOVA, with the Bonferroni all-pair-wise multiple comparison. Differences in means between two groups were analysed by the unpaired Student's *t* test. Differences between non continuous variables and percentages were tested by χ^2 analysis. Correlations between two variables were calculated with least squares regression analysis. Logistic regression was used to identify the significant independent factors associated with diagnosis of nosocomial infection. A 5% significance level was used in all comparisons.

Results

The global infection rate was 7.6 per 1000 bed days and 59% of the patients had nosocomial infections. One hundred and sixteen patients did not develop any nosocomial infection, 38 patients suffered one infection, 28 suffered two infections and three patients had three infections during their stay in hospital. The most common infection site was the urinary tract (*n*=63, 62%). Eleven (17%) of the urinary tract infections were in catheterised patients. Thirty infections were respiratory tract infections, and 10 were miscellaneous sites of infection (diverticulitis, vascular infection, skin and soft tissue infection). There were no primary bacteraemia and eight secondary bacteraemia during the study. One hundred and three infections were recorded. The most common micro-organisms present were *Escherichia coli* (*n*=40, 39%), *Enterococcus faecalis* (*n*=15, 14%), *Staphylococcus aureus* (*n*= 8, 8%), *Pseudomonas aeruginosa* (*n*=7, 7%), *Proteus mirabilis* (*n*=7, 7%), *Klebsiella pneumoniae* (*n*=5, 5%) and *Enterobacter cloacae* (*n*=4, 4%). Most of them were identified by urine culture. The urinary tract was the most frequent source of bacteraemia (*E. coli* (*n*=5), *Pseudomonas* (*n*=1) and *S. aureus* (*n*=1)), and two patients had pneumococcal bacteraemia. Two wound cultures were positive with *S. aureus*. Serum samples obtained for serological diagnosis in nine patients were negative.

Three groups were defined: one for patients who did not develop an infection during their stay in hospital, one for those who suffered one infection, and one for those who suffered more than one infection. As presented in Table 1, the three groups differed in terms of age, gender ratio, MMS and length of stay. The group who did not develop an infection was younger than the other two groups (P=0.002 and P=0.001, respectively) and had a better mental score (P=0.012 and P<0.001, respectively). On the other hand, the group who suffered more than one infection was hospitalised during a longer period than those with no infection (P<0.0001) and with one infection (P=0.009). The three groups did not differ significantly according to the main reasons for hospital admission in acute wards. There was no difference in the type of infectious events occurring in the two groups of infected patients (Table 2).

The proportion of patients with BMI <20 did not differ significantly among the three groups (respectively 24.6/34.2/41.9%).Their nutritional status is presented in Table 3. All anthropometric parameters differed among the three groups, except TST which fell short of statistical

Table 1. Characteristics of the patients

	No infection	One infection	>One infection	
n	116	38	31	*P*
Age (years)	80.0 ± 0.7	84.4 ± 1.2	85.2 ± 1.3	0.0002
Gender (M/F) (*n*)	37/79	3/35	5/26	0.006
MMS	23.7 ± 0.7	20.1 ± 1.4	18.1 ± 1.5	0.0005
Length of stay (days)	60.1 ± 4.9	78.9 ± 10.7	122.2 ± 19.5	<0.0001
Time of infection after admission (days)		44.7 ± 10.4	22.0 ± 3.8	0.0293
Main reasons for hospital admission				0.143
Medical disorders				
Neurological	56.5%	17.4%	26.1%	
Cardio-pulmonary	61.9%	14.3%	23.8%	
Others	63.7%	22.7%	13.6%	
Surgical disorders				
Hip fracture	58.2%	25.3%	16.5%	
Joint prosthesis	100%	0%	0%	
Others surgical procedure	53%	23.5%	23.5%	

MMS, mini-mental state.

Differences between non continuous variables and percentages were tested by χ^2 analysis.

Differences in means among three groups were analysed by ANOVA.

Differences in means between two groups were analysed by the unpaired Student's *t* test.

Table 2. Infection sites of the 103 nosocomial infections

Groups	One infection	>One infection
Urinary tract infections (*n*)	24	39
Respiratory infections (*n*)	11	19
Other infections (*n*)	3	7

The two groups were compared by χ^2 analysis.

significance (P=0.064). The group with more than one infection had lower body weight (P=0.002) and MAC (P=0.011) than the non-infected one and a lower BCT than that with one infection (P=0.003). Total energy and protein intakes also differed among the three groups. The group with no infection had higher daily nutrient intake than the other two groups (P=0.004 and P<0.0001, respectively).

As far as biological data were concerned (Table 4), albumin, transthyretin, and CRP levels differed significantly among the three groups (respectively P<0.0001, P<0.0001 and P=0.0003). The group with several infections had a mean albumin level below the normal range (35–48 g/l) and lower than the other two groups (P<0.0001 and P=0.006, respectively). The non-infected group had higher transthyretin levels (P=0.013 and P<0.0001, respectively) and lower CRP levels (P=0.005 and P=0.001, respectively) than the two groups with infections.

Finally, other factors that might be associated with the risk for nosocomial infections were studied (Table 5). The presence of an indwelling urinary catheter (n=13) was more frequent in the infected two groups and was associated with the occurrence of a urinary tract infection (69.2% [n=9] versus 20.7% [n=37] in patients without a catheter; P<0.0001). On the other hand, it was not related to sex (M 6.7% [n=3] versus F 5.6% [n=8]; P=0.797). The difficulties with swallowing tended to be more frequent in the group with more than one infection but were not related to the occurrence of respiratory infections. The presence of pressure sores was not more frequent in the infected groups. However, these results should be interpreted with caution since we had not determined the functional status or other underlying diseases that may increase the risk of nosocomial infection in our study. Further studies are needed to explore this point.

The three groups of patients differed in terms of outcome (P=0.0077). A higher proportion of patients from the group without infection (76.9 %) could return home after being discharged from our department. On the other hand, infected patients had a higher risk of mortality during their stay in hospital (20.5 and 30.7%, respectively, versus 4.3%).

The variables that were associated by unifactorial analyses with the development of an infectious episode, were tested by multivariate analysis: two groups of variables were considered separately, depending on whether they were related to the patient or were extrinsic risk factors (Table 6). Age and albumin level on one hand, energy intake, length of hospital stay and the presence of a urinary catheter on the other hand, were independent risk factors.

Discussion

This study shows that nosocomial infections and undernutrition are common and interrelated among older patients

Table 3. Anthropometric variables and energy intake in the three groups of patients

	No infection	One infection	>One infection	
n	116	38	31	*P*
Weight (kg)	61.2 ± 1.5	58.9 ± 3.1	51.3 ± 1.7	0.0079
BMI (kg/m^2)	23.8 ± 0.5	24.0 ± 1.2	21.2 ± 0.7	0.046
MAC (cm)	27.1 ± 0.4	26.7 ± 1.0	24.1 ± 0.7	0.011
TST (mm)	11.6 ± 0.5	12.9 ± 1.3	9.5 ± 0.8	0.064
BST (mm)	4.9 ± 0.3	5.9 ± 0.9	3.1 ± 0.3	0.011
Energy intake (kcal/day)	1717 ± 40	1474 ± 91	1284 ± 74	<0.0001
Energy intake (kcal/kg/day)	29.3 ± 0.8	27.2 ± 2.1	25.1 ± 1.4	0.089

BMI, body mass index; MAC, mid-arm circumference; TST, tricipital skinfold thickness; BST, bicipital skinfold thickness.
The three groups were compared by ANOVA.

Table 4. Biological variables in the three groups of patients

	No infection	One infection	>One infection	
n	116	38	31	*P*
Albumin (g/l)	36.3 ± 0.4	34.6 ± 0.6	31.7 ± 0.9	<0.0001
Transthyretin (g/l)	0.26 ± 0.01	0.23 ± 0.01	0.19 ± 0.01	<0.0001
Orosomucoid (g/l)	2.1 ± 0.7	1.5 ± 0.1	1.6 ± 0.1	0.861
CRP (mg/l)	16 ± 2	37 ± 10	44 ± 8	0.0003
Lymphocytes (g/l)	1.7 ± 0.1	1.8 ± 0.3	1.5 ± 0.1	0.438
PMN leukocytes (g/l)	4.4 ± 0.2	6.1 ± 1.0	6.7 ± 0.7	0.0027

PMN, polymorphonuclear.
The three groups were compared by ANOVA.

Table 5. Association of clinical characteristics with infection

	No infection	One infection	>One infection	
n	116	38	31	*P*
Urinary catheter	2	6	5	
	1.7%	15.0%	15.6%	0.0015
Difficulty with swallowing	7	2	4	
	5.9%	5.0%	12.5%	0.373
Pressure sores	15	10	9	
	12.7%	25.0%	28.1%	0.055
Outcome				<0.0001
Nursing home	18	9	13	
	15.4%	22.5%	40.6%	
Return home	90	22	10	
	76.9%	55.0%	31.3%	
Death	5	8	9	
	4.3%	20.0%	28.1%	
Hospitalisation	4	1	0	
	3.4%	2.5%	0%	

The three groups were compared by χ^2 analysis.

Table 6. Multivariate analysis of factors associated with the development of an infection

	P	OR [95% CI]
Intrinsic factors (personal)		
Age	0.035	1.06 [1.003–1.12]
Weight	0.811	1.003 [0.98–1.03]
Albumin	0.027	1.11 [1.01–1.21]
PMN leukocytes	0.031	1.17 [1.01–1.36]
Sex	0.075	2.51 [0.91–6.94]
Extrinsic factors		
Length of stay	0.009	1.01 [1.002–1.01]
Urinary catheter	0.005	44.1 [3.2–611.7]
Daily intake	<0.0001	1.002 [1.001–1.002]

PMN polymorphonuclear

hospitalised in a rehabilitation unit. The global infection rate was 7.6 per 1000 bed days. The most frequent infection sites were the urinary and respiratory tracts. Previous studies have reported slightly higher infection rates: 10.6 per 1000 bed days in a rehabilitation ward [12] and 10.3 per 1000 bed days in an acute geriatric care [20]. We found that older age was one of the factors identified as being associated with NI. This study agrees with the fact that elderly patients are at a particularly high risk of developing nosocomial infection. Nevertheless, the frequency of infection remains probably underestimated in the elderly because infections can be difficult to diagnose, some of them may present atypically or without febrile responses [21, 22].

In our study, the presence of a urinary catheter was the major determinant for NI (OR >63). The high prevalence of NI occurring in the urinary tract, most often secondary to an indwelling urinary catheter, is well known [23–25]. According to Hussein and co-workers [12], urinary catheters on admission and antibiotherapy during the previous month are more frequent in old patients admitted in rehabilitation wards than in those hospitalised in acute geriatric wards.

The main objective of our study was to evaluate the association of malnutrition with nosocomial infections. The prevalence of undernutrition as evaluated by BMI <20, was 29.5% in our population, which agrees with data reported in the literature. It did not differ significantly among the non-infected patients and those with one or more than one infection. Anthropometric variables and serum nutritional protein levels were comparable between non-infected patients and those with one infection. However, our finding that these variables were more severely altered in patients with more than one infection, strongly suggests that protein energy malnutrition may favour multiple infections. Discrepant results have been reported about the association between malnutrition and nosocomial infections in elderly people [7, 12, 14–16]. This could be explained by the difference in the patient's setting. Thus, Harkness and co-workers [13] showed that malnutrition in the elderly defined in terms of malnourished appearance and weight loss within the last 30 days, was one of the predisposing factors for nosocomial pneumonia in a long-term care facility but not in an acute care setting. Morever, the parameters which are the most commonly used to evaluate the nutritional status, are weight or albumin and sometimes BMI. Even if these useful indicators correlate with mortality and morbidity [26–29], a single measurement of one of them is not of value in individual patients. They lack specificity and sensitivity to detect modifications of the nutritional status [30, 31]. Although albumin represents about half of total body visceral protein, there are several reasons why albumin levels fail to discriminate between patients with normal and abnormal nutritional status. Various illnesses such as hepatic failure, or systemic inflammatory response following injury, infection or inflammation, may alter its synthesis by the liver. Patient's body weight depends on the state of hydration and may be increased if the patient is overhydrated. The analysis of several nutritional variables or their combination as clinical scores is more relevant [31–33]. Thus, Schneider and colleagues [34] using a nutritional risk index (NRI) including usual body weight, actual body weight and serum albumin level, recently demonstrated in a 3-day survey that malnutrition measured in 1637 in-patients from a French university

hospital aged 61 years old, was an independent risk factor for NI. However, it could not be stated whether infection resulted from or led to malnutrition. Our results indicate that an altered nutritional status may facilitate the occurrence of nosocomial infections since the nutritional assessment based on several anthropometric variables and biological markers was done on admission.

An important finding in our study relates to the association of nosocomial infections with lower energy intake, which could not meet energy needs in such patients with a catabolic state and therefore might increase the risk of protein energy malnutrition. A number of studies have shown that artificial nutrition reduced complications especially infections in malnourished surgical patients [35–38]. Therefore, evaluation of daily intake along the stay in hospital, is fundamental to identify patients who would benefit from nutritional support.

Another independent factor we found to be associated with NI, was the length of hospital stay. A striking difference was observed between patients with no or one infection and those with more than one infection who stayed in hospital twice as long as the former ones. Prolonged hospital stay has been described as a risk factor for development of nosocomial infections and conversely the latter have been shown to increase the length of hospital stay [12, 16], which may favour nutritional depletion during hospitalisation. Older patients have longer hospital stays and prolonged recovery owing to the severity and multiplicity of underlying diseases; extended periods of stay contribute to longer duration of exposure to pathogens and invasive procedures in the hospital settings.

The poor prognosis of nosocomial infections in old people has been confirmed in our study. Patients with multiple nosocomial infections showed an increased mortality (28.1%) and discharge to nursing-home. In the literature, the mortality rate has been estimated from 13.6 to 43% in old patients with nosocomial infection [12, 14, 16].

In summary, this study shows that elderly patients hospitalised in rehabilitation units were at particularly high risk of nosocomial infections and that 20% of them presented multiple infections. These latter patients were older, presented an altered nutritional status, had lower food intake, had more urinary catheters, showed a prolonged recovery, increased mortality and had more discharge placement. A better understanding of the predisposing factors for nosocomial infection in elderly hospitalised patients may allow some preventing strategies to reduce the risk. A reduction in the number of invasive procedures, particularly urinary catheterisation, a nutritional assessment on admission and if necessary, a nutritional intervention, may help to reduce the incidence of nosocomial infections.

Key points

- The incidence rate of noscomial infections was 59% and the global infection rate was 7.6/1000 bed days.
- Age, energy intake, length of hospital stay and the presence of a urinary catheter were independent risk factors of nosocomial infection.
- The clinical outcome was significantly different between patients with more than one nosocomial infection as compared with those with no or with one nosocomial infection.

Conflicts of interest

None. Patients were informed of the purpose of the study in writing and gave their oral consent.

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