Original

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BAHNG score: predictive model for detection of subjects with the oropharynx colonized by uncommon microorganisms

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ABSTRACT

Objective. Pneumonia is most frequently produced by the microaspiration of flora that colonizes the oropharynx. Etiological diagnosis of pneumonia is infrequent in clinical practise and empirical treatment should be prescribed. The aims of the present study were to determine the factors associated with oropharynx colonization by uncommon microorganisms (UM) and to develop a predictive model.

Methods. A cross-sectional study that included all patients living in one long-term care facilities was developed. Demographic, comorbidities, basal functional status and clinical data were collected. To determinate the oropharyngeal colonization, a single sample of pharynx was obtained for each subject using a cotton swab.

Results. A total of 221 subjects were included, mean age 86.27 (SD 8.05) years and 157 (71%) were female. In 32 (14.5%) subjects UM flora was isolated, Gram-negative bacilli in 16 (7.2%) residents, and *Staphylococcus aureus* in 16 (7.2%). The predictive model included the presence of hypertension, neuromuscular disease, Barthel < 90 and use of PEG. The BAHNG score (**BA**rthel, **H**ypertension, **N**euromuscular, **G**astrostomy), showed an area under the curve of 0.731 (CI 95% 0.643-0.820; p<0.001). We have classified patients according to this score in low (0-2 points), intermediate (3-5 points) and high risk (≥ 6). The probability of UM colonization in the oropharyngeal based on this classification is 4.1%, 15.8% and 57.1% for low, intermediate and high risk, respectively.

Conclusion. The BAHNG score could help in the identifications of elderly patients with high risk of colonization by UM. In case of pneumonia the evaluation of the subject through this score could help in the initial decisions concerning antibiotic treatment.

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Escala BAHNG: modelo predictivo para la detección de sujetos colonizados en la orofaringe por microorganismos menos habituales

Objetivo. La neumonía se produce, con mayor frecuencia, por la microaspiración de la flora que coloniza la orofaringe. Su diagnóstico etiológico es infrecuente en la práctica clínica, prescribiéndose el tratamiento empíricamente. El objetivo del presente estudio fue determinar los factores asociados con la colonización de la orofaringe por microorganismos menos habituales y desarrollar un modelo predictivo.

Métodos. Se realizó un estudio transversal que incluyó a todos los pacientes ingresados en una residencia de larga estancia. Se recogieron datos demográficos, comorbilidades, estado funcional basal y datos clínicos. Para determinar la colonización orofaríngea, se obtuvo una muestra única de la faringe para cada sujeto con un hisopo de algodón.

Resultados. Se incluyeron un total de 221 sujetos, con una edad media de 86,27 (DE 8,05) años y 157 (71%) fueron mujeres. En 32 (14,5%) sujetos se aisló flora menos habitual: bacilos gramnegativos en 16 (7,2%) residentes y *Staphylococcus aureus* en 16 (7,2%). El modelo predictivo incluyó la presencia de hipertensión, enfermedad neuromuscular, Barthel <90 y tener gastrostomía endoscópica percutánea. La escala BAHNG (**BA**rthel, **H**ipertensión, **N**euromuscular, **G**astrostomía) mostró un área bajo la curva de 0,731 (IC 95% 0,643-0,820; p <0,001). Se clasificó a los pacientes según la puntuación en bajo (0-2 puntos), intermedio (3-5 puntos) y alto riesgo (≥ 6). La probabilidad de colonización de la orofaringe por microorganismos menos habituales según esta clasificación fue del 4,1%, 15,8% y 57,1% para el riesgo bajo, intermedio y alto, respectivamente.

Conclusión. La escala BAHNG podría ayudar en la iden-

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tificación de pacientes ancianos con alto riesgo de colonización de la orofaringe por microorganismos menos habituales. En caso de neumonía, la evaluación del sujeto a través de esta escala podría ayudar en las decisiones iniciales sobre el tratamiento antibiótico a instaurar.

INTRODUCTION

Pneumonia is most frequently produced by the microaspiration of flora that colonizes the oropharynx. Colonization of the oropharynx may favour pneumonia due to unusual microorganisms (UM) through microaspiration[1-5]. This is more common in older adults compared to younger patients, occurring in up to half of older patients hospitalized for pneumonia[2,3]. The incidence of community-acquired pneumonia increases with age, reaching 25 to 35 cases per 1000 inhabitants/year in the population over the age of 65 years. This disease is associated with an elevated morbi-mortality and it is a frequent cause of emergency care and hospital admission[6-9].

Multiple factors have been described as cause of bacterial colonization, such as age, comorbidity, basal functional status, antimicrobial use, presence of devices, indwelling devices and prior contact with health centres or long-term care facilities[10-14]. One of the major risk factors for developing methicillin-resistant *Staphylococcus aureus* (MRSA) infection is to be colonised by this microorganism. This situation increases the risk of severity infections and mortality[13-17]. Long-term care facilities has been describe as an important risk factor for infection by UM, although in the last years this concept has been reviewed due to the different types of care received by people living in there[18,19].

Finally, etiological diagnosis of pneumonia is infrequent in clinical practise and empirical treatment should be prescribed based on the clinical profiles of the patients and the risk factors for infections by UM. Therefore, it is important to identify which patients may have infection by UM to avoid undertreatment or an excessive use of wide broad-spectrum antimicrobials.

Taking the above into account, the aims of the present study were as follows: (a) to determine the factors associated with oropharynx colonization by UM among subjects residing in a long-term care facilities; (b) and to develop a predictive model in these patients.

METHODS

Study design. A cross-sectional study that included all patients living in the "Gran Residencia" was performed during August 2015. During a single day for each patient, we collected an oropharyngeal sample for culture and the information about the variables included in the study. The staff of the "Residencia Gran Madrid" was responsible for the data and sample collection. These staffs were blinded for the culture results. The staffs of the microbiology laboratory were blinded for the patient's data. The study was approved by the Ethical Committee of the Clínico San Carlos Hospital and all the patients or tutors consented to participate in the study.

Patient selection. We included all patients admitted in the "Gran Residencia" in which the consent was obtained.

Study setting. "Gran Residencia" is a long-term care facilities with 360 residents and belongs to the Community of Madrid. People living in it have different health-care requirements. Both nurse and medical personnel works in it. There is no radiologic or analytical test *in situ* available for diagnosis. The medication is usually administered orally and only exceptionally intravenously.

Definition and collection of variables. Demographic data (age and gender), comorbidities (Charlson comorbidity index), basal functional status (Barthel index) and clinical data (medications, vaccination status, existence of dysphagia, percutaneous endoscopic gastrostomy tube placement (PEG) and number of antibiotics treatments, hospital admissions and visits to the Emergency Department during the previous 12 moths) were registered in the moment that the oropharyngeal sample was collected. Severe comorbidity was determined as a Charlson's Comorbidity index of 3 or more points[20]. The variables were registered in an electronic data collection notebook. The primary outcome was the isolation of a microorganism that does not belong to the usual oropharyngeal flora (alpha-haemolytic *Streptococcus viridans* and *Neisseria* spp).

Microbiology assessments. To determinate the oropharyngeal colonization, a single sample of pharynx was obtained for each subject using a cotton swab that subsequently was introduced into a Stuart transport medium. Swabs were cultured in standart media (COS and PVX, BioMerieux®, Marcy-l´Étoile, France). We identified *Staphylococcus aureus* using mass spectrometry MALDI-TOF (MALDI Biotyper, Bruker Co, Billerica, Massachusetts, USA). MICs were determined using

Table 1 | **Microorganism isolated in the residents.**

Gram-negative	**16**	**7,2**
Enterobacter cloacae	1	0,5
Escherichia coli	1	0,5
Klebsiella azaenae	1	0,5
Klebsiella pneumonia	5	2,3
Morganella morganii	1	0,5
Proteus mirabilis	2	0,9
Proteus vulgaris	1	0,5
Providencia stuartii	1	0,5
Pseudomonas aeruginosa	1	0,5
Raoultella ornithinolytica	1	0,5
Stenotrophomonas maltophilia	1	0,5
Gram-positive	**16**	**7,2**
Methicillin-susceptible *Staphylococcus aureus*	6	2,7
Methicillin-resistant *Staphylococcus aureus*	10	4,5
Usual oropharyngeal flora[a]	189	85,6

[a]**Usual oropharyngeal flora: alpha-haemolytic *Streptococcus viridans* and *Neisseria* spp.**

Table 2 **Characteristics of the subjects included in the study based on the isolation or not of common microorganism in the oropharynges [n(%)].**

	All Patients (n=221)	Common Flora (n=189)	Uncommon Flora (n=32)	P Value
Demographic variables				
Age (years) (mean (SD))	86.27 (8.05)	85,95 (8.31)	88,16 (6.09)	0.223
Female (n(%))	157 (71)	135 (71.4)	22 (68.8)	0.757
Medical history				
Hypertension	171 (77.4)	141 (74.6)	30 (93.8)	0.017
Diabetes without end-organ damage	32.1	64 (33.9)	7 (21.9)	0.179
Diabetes with end-organ damage	33 (15)	30 (16)	3 (9.4)	0.335
Moderate or severe renal disease	45 (20.4)	38 (20.1)	7 (21.9)	0.818
Myocardial infarction	19 (8.6)	15 (7.9)	4 (12.5)	0.394
Congestive heart failure	59 (26.7)	49 (25.9)	10 (31.2)	0.529
Peripheral disease	45 (20.4)	40 (21.2)	5 (15.6)	0.472
Cerebrovascular disease	62 (28.1)	51 (27.0)	11 (34.4)	0.389
Hemiplegia	20 (9)	18 (9.5)	2 (6.2)	0.551
Connective tissue disease	2 (0.9)	2 (1.1)	0 (0)	0.559
Dementia	95 (43.0)	80 (42.3)	15 (46.9)	0.631
Chronic pulmonary disease	41 (18.6)	35 (18.5)	6 (18.8)	0.975
Moderate or severe liver disease	14 (6.3)	11 (5.8)	3 (9.4)	0.445
Mild liver disease	12 (5.4)	9 (4.8)	3 (9.4)	0.287
Peptic ulcer disease	20 (9)	17 (9)	3 (9.4)	0.945
Oesophageal disease	101 (45.7)	85 (45)	16 (50)	0.598
Leukaemia	1 (0.5)	1 (0.5)	0 (0)	0.680
Lymphoma	0 (0)	0 (0)	0 (0)	-
Tumour without metastasis	28 (12.7)	24 (12.7)	4 (12.5)	0.975
Metastatic solid tumour	0 (0)	0 (0)	0 (0)	-
AIDS	0 (0)	0 (0)	0 (0)	-
Neuromuscular disease	4 (1.8)	2 (1.1)	2 (6.2)	0.042
Flu vaccination	167 (75.6)	140 (74.1)	27 (84.4)	0.210
Pneumococcal vaccine	49 (22.2)	44 (23.3)	5 (15.6)	0.335
Visit to Emergency Department	7 (3.2)	7 (3.7)	0 (0)	0.274
PEG	3 (1.4)	1 (0.5)	2 (6.5)	0.009
Previous antibiotics (≥ 3 cycles)	18 (8.1)	17 (9)	1 (3.1)	0.262
Previous admission to hospital	64 (29.5)	53 (28.3)	11 (26.7)	0.353
Treatment				
ACEi	53 (24.3)	44 (23.7)	9 (28.1)	0.586
Omeprazole	144 (66.1)	122 (65.6)	22 (68.8)	0.727
Use > 3 different types of medicine a day	210 (95)	178 (94.2)	32 (100)	0.162
Severe comorbidity	105 (47.5)	92 (48.7)	13 (40.6)	0.399
Barthel < 90	143 (64.7)	117 (61.9)	26 (81.2)	0.034

PEG: percutaneous endoscopic gastrostomy tube placement; ACEi: angiotensin converting enzyme inhibitors

Table 3 Independent variables associated to patient's colonization by uncommon microorganism.

	Odd Ratio	95%CI		P value
Hypertension	5.012	1.055	23.803	0.043
Neuromuscular disease	20.554	2.242	188.400	0.007
PEG	8.394	0.695	101.340	0.094
Barthel < 90	3.240	1.128	9.304	0.029

CI: confidence interval; PEG: percutaneous endoscopic gastrostomy tube placement

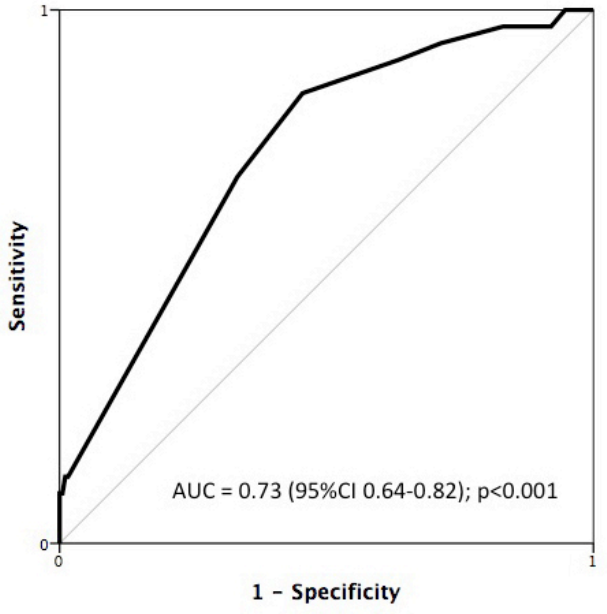

Figure 1 ROC curve and area under curve (AUC) of BAHNG score to predict the isolation of uncommon microorganism.

authomatic dilution methods (WIDER system, Francisco Soria Melguizo SA, Madrid, Spain) and E-test technique (Ab Biodisk Solna, Sweden), and interpreted following CLSI Standards.

Statistical analysis. The quantitative variables are expressed as mean and standard deviation and the qualitative variables are expressed as absolute values and percentages. The Chi-square or the Fisher exact tests were used if more than 25% of the expected frequencies were less than 5 for the qualitative variables, and the Student's t test was used to analyse the quantitative variables. Logistic regression was used to evaluate the probability of isolation of an uncommon microorganism, including the variables that in the univariate analysis obtained p <0.20. The selection of the multivariable model was based on the statistical significance. The goodness of fit was assessed with the Hosmer-Lemeshow and discrimination with the analysis of the curve of the receiver operating characteristic (ROC). A prediction rule was developed for the isolation of uncommon microorganism, generated from logistic regression model, using a scoring method based on the regression coefficient. The overall risk of isolation of uncommon microorganism was calculated by adding the scores for each component.

ROC curves were constructed for the adjusted model. The area under the curve (AUC) and their confidence intervals at 95 % (CI 95%) were shown, as well as the odds ratios and CI 95%. In all the tests of significance, the null hypothesis was rejected with an α error less than 0.05. The statistical analyses were performed using the statistical package SPSS 20.0 software (SPSS Inc., Chicago, Illinois, USA).

RESULTS

The number of subjects finally included was 221, since it could

Table 4 | **BAHNG score for the isolation of uncommon microorganism.**

	Value of each item
Neuromuscular disease	6
PEG	4
Hypertension	3
Barthel < 90	2

It must be added the points assigned to each variable to obtain a total score (0-16 points)
Low risk: 0-2 points; Intermediate risk: 3-5 points; High risk: ≥6 points.

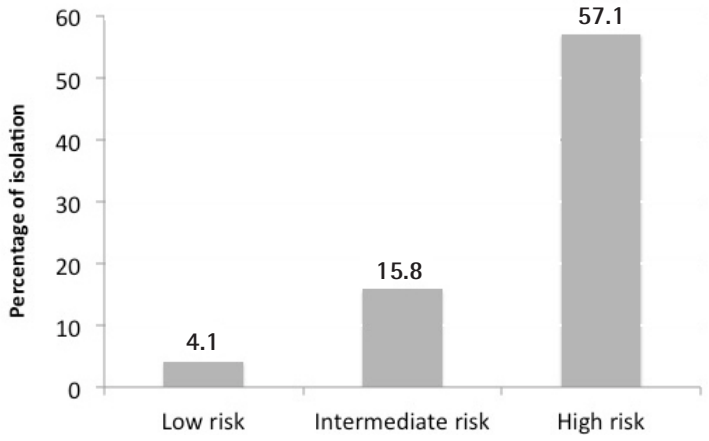

Figure 2 | **Probability of isolation of uncommon microorganism based on the BAHNG score.**

Low risk: 0-2 points; Intermediate risk: 3-5 points; High risk: ≥6 points.

not be obtained the consent for the remaining residents (139). The mean age was 86.27 (SD 8.05) years and 157 (71%) were female. In 32 (14.4%) subjects, uncommon oropharyngeal flora was isolated. These results (table 1) showed Gram-negative bacilli in 16 (7.2%) residents, *S. aureus* in 16 (7.2%) and MRSA in 10 (4.5%).

Table 2 shows the characteristics of the patients and the univariate analyses based on the isolation or not of UM. There were no statistical differences in relation to Charlson index, numbers of treatments taken, previous antibiotics cycles ≥ 3 or admission to hospitals.

Table 3 shows the results of the multivariate analyses. The final model included the presence of hypertension, neuromuscular disease, Barthel < 90 and use of PEG. This new model, the BAHNG score (**BA**rthel, **H**ypertension, **N**euromuscular, **G**astrostomy), showed an AUC of 0.731 (CI 95% 0.643-0.820; p<0.001) to predict the isolation of UM in the oropharyngeal (figure 1). Table 4 describes the score of each item for calculating the total result of the BAHNG score. We have classified patients according to this score in low (0-2 points), intermediate (3-5 points) and high risk (≥ 6). The probability of unusual pathogens colonization in the oropharyngeal based on this classification is 4.1%, 15.8% and 57.1% for low, intermediate and high risk, respectively (figure 2).

DISCUSSION

The present study has developed a risk score for uncommon oropharyngeal colonization in subjects living in long-term care facilities. The BAHNG score shows a good discriminatory capacity and allows the identification of elderly patients with a high risk of colonization by not usual microorganism. This score classifies subject in 3 risk groups, depending of the achieve points: 4.1% for score of 0-2 points, 15.8% for 3-5 points, and 57.1% for more than 5 points.

There are lots of articles describing different risk factors for colonization[10,12-15,21]. Most of these published articles are limited to describe the associated risk factors, without providing a risk assessment based on the number and weight of the criteria that the patient can meet. The main advantage of the present study is giving a tool to classify this risk, which could

facilities the initial clinical decisions. The clinical relevance of the BAHNG score is due to the following facts. First, pneumonia is most frequently produced by the microaspiration of flora that colonizes the oropharynx[2]. Second, in most cases treatment must be empiric due to the absence of etiologic diagnosis, despite the microbiological diagnosis includes the performance of blood cultures, staining and culture of respiratory samples and the detection of bacterial antigens[22]. Finally, in elderly patients with functional impairment is more difficult to obtain an evaluable sputum sample[23].

The BAHNG score include 4 variables: functional status (using Barthel), hypertension, neuromuscular disease and PEG. The functional situation has been associated with a greater speed of colonization by MRSA and Gram-negative bacteria[21]. Basal functional status has even been described as main determining factor to be colonized by Gram-negative bacilli[24]. Chronic neurological diseases[5,13,25] and PEG[26] also have been previously described as a risk factor for Gram-negative bacilli and *S. aureus* colonization. In own knowledge, hypertension has not been previously described as a risk factor for colonization. However, evidence suggests that low-grade inflammation plays a key role in the pathogenesis of hypertension and colonization can be a mechanism leading to the activation of non-acute inflammation[27]. Moreover, it has been reported that cardiovascular disease and hypertension may increase the risk of infection[11,28].

On the other hand, severe comorbidity, previous antibiotics therapy or hospitalization, are variables previously related to colonization[29], but in our study does not reach statistically significant in the univariate analysis. However, unlike our study, the aim of these studies was found risk factors for multidrug-resistance microorganism, especially MRSA. Moreover, the value of these risk factors are especially important if these circumstances occur in the last month or in the last 3 months, while we have assessed the situation for 12 months.

The present study has certain limitations. There may be a selection bias because an important number of residents did not consent to participate in the study. Besides, further studies are needed to carry out an external validation of the score or an intervention study in order to demonstrate the potential benefits in making decisions guided by the BAHNG score

Despite this, we can conclude that the BAHNG score could help in the identifications of elderly patients with high risk of colonization by uncommon microorganism. In case of pneumonia the evaluation of the subject through this score could help in the initial decisions concerning antibiotic treatment.

CONFLICTS OF INTEREST

None to declare

FUNDING

None to declare

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