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Predictors of pneumonia in acute stroke patients admitted to a neurological intensive care unit

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Abstract *Objective* To determine independent clinical predictors of stroke-associated pneumonia (SAP) that are available in all patients on day of hospital admission. *Methods* We studied 236 patients with acute ischemic stroke admitted to the neurological intensive care unit at our university hospital. Risk factors of SAP and of non-responsivity of early-onset pneumonia (EOP; onset within 72 hours after admission) to initial antibacterial treatment were analyzed. *Results* Incidence of SAP was 22%. The following independent risk factors were found to predict SAP with 76% (EOP: 90%) sensitivity and 88% specificity: dysphagia (RR, 9.92; 95% CI, 5.28–18.7), National Institute of Health Stroke Scale ≥ 10 (RR, 6.57; CI, 3.36–12.9), non-lacunar basal-ganglia infarction (RR, 3.10; CI, 1.17–5.62), and any other infection present on admission (RR, 3.78; CI, 2.45–5.83). Excluding the patients with other infections on admission, the same independent risk factors (except infection) were found. Further, but not independent risk factors were: combined brainstem and cerebellar infarction, infarction affecting more than 66% of middle cerebral artery territory, hemispheric infarction exceeding middle cerebral artery territory, impaired vigilance, mechanical ventilation, age ≥ 73 years, current malignoma, and cardioembolic stroke, whereas patients with lacunar infarctions had significantly lower risk. In contrast to previous reports, no impact of male gender or diabetes was found. Initial vomiting, especially if associated with impaired vigilance, predicted antibacterial treatment non-responsivity of EOP. In non-responders exclusively fungal pathogens were identified. *Conclusion* Increased risk of pneumonia in acute stroke patients can be sufficiently predicted by a small set of clinical risk factors.

Key words · pneumonia · dysphagia · basal ganglia · ischemic stroke · stroke-induced · immunosuppression

Introduction

Pneumonia is one of the most frequent complications in acute stroke patients, with reported incidences of 2.4–47%, depending on type of treating unit and stroke severity of studied population [1–5]. Stroke-associated pneumonia (SAP) is the leading cause of death in the postacute phase of stroke, accounting for approximately 30% of 30-day mortality [2].

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As yet, there are only limited data available on independent predictors of SAP in acute stroke patients treated on intensive care units. Previous studies analyzed smaller samples of patients [1, 3, 5], or patients selected for a pharmaceutical study [6]. In these studies, a number of risk factors have been reported, such as higher baseline National Institute of Health Stroke Scale (NIHSS) and age, lower baseline Barthel Index and Glasgow Coma Score (GCS), male gender, diabetes, stroke subtype and location, dysphagia and mechanical ventilation. Despite the well-documented association of stroke-associated infections with increased mortality and worse long-term outcome [1, 2], and despite encouraging results of prophylactic antibiotic treatment in an animal stroke model [7], studies on early antibiotic prophylaxis after stroke failed to show a benefit in patients outcome [8, 9]. This might be due to inclusion also of patients with low risk of developing infection in these studies. To improve efficacy of preventive therapies, the determination of independent SAP predictors is desirable.

Considering the various SAP risk factors previously reported, the present study was conducted to determine independent clinical predictors of SAP in a larger sample of acute ischemic stroke patients treated on an neurological intensive care unit (NICU). In view of the potential application for patient's selection to early preventive antibiotic therapy, we focussed on predictors available on day of hospital admission. In a post-hoc analysis, we also analyzed risk factors of non-responsivity to empirical antibiotic therapy in early-onset pneumonia.

Patients and Methods

Study population

We prospectively studied patients with acute ischemic stroke who were consecutively admitted to the NICU of the Neurological Department at Rostock University Hospital over a one-year period. The NICU has eight beds, four of these equipped with respirator, and another four without respirator (Stroke Unit), and an annual inpatient count of approximately 600 patients with 500 ventilator days per year. The presence of acute ischemic stroke was defined in all patients in whom the time interval between symptom onset and NICU treatment was less than 24 hours and in whom the ischemic brain lesion was clearly assessed in cerebral CT or MRI. If initial and follow-up cerebral CT/MRI failed to detect an acute ischemic brain lesion the respective patient was excluded from this study. Of all acute stroke patients with an NICU stay of at least 24 hours a standardized set of demographic, clinical and laboratory data was obtained, including detailed information related to SAP as specified below.

Data collection

Baseline data included age, gender, and presence of diabetes, malignoma, smoking, and heavy drinking. A female (male) patient was considered heavy drinker if reporting a regular mean alcohol consumption of more than two (three) drinks per day, i.e. 20 (30) g ethanol, according to the criteria defined by the National Institute on Alcohol Abuse and Alcoholism. Infection was regarded as present on admission if there was a positive history and/or clinical signs of any current infection except pneumonia, in combination with elevated levels of C-reactive protein (CRP) or leukocytes on admission. Within the first 24 hours after admission, severity of neurological deficit was assessed using the NIHSS [10]. Consciousness was assessed and considered impaired at GCS < 13 [11]. In the same time window, the presence and severity of dysphagia was screened in all study subjects. For this, a subtle clinical examination and a water swallowing test with pulse oximetry was performed, a drop of ≥2% in the arterial oxygen saturation within 2 minutes after swallowing was considered clinically significant to detect dysphagia with silent aspiration or with cough [12]. Severity of dysphagia was scored as follows: score 0, no dysphagia; 1, dysphagia with silent aspiration or with cough; 2, dysphagia with impaired voice; 3, complete dysphagia without swallowing. Occurrence of initial vomiting was documented. Cerebral CT- or MRI-documented infarctions were classified according to the affected vascular territory. Middle cerebral artery (MCA) infarctions were further subdivided according to size and location of the lesion (1, lacunar; 2, non-lacunar, basal ganglia; 3, non-lacunar, subcortical; 4, cortico-subcortical; I, non-lacunar, <33%; II, 33–66%; III, >66% of the MCA territory affected). Lacunar infarction was defined as subcortical or basal-ganglia lesion with a diameter ≤15 mm. After completion of diagnostic procedures that included head CT and/or MRI, doppler and/or color-coded duplex sonography of extra- and intracranial brain-supplying vessels in each patient, and transesophageal echocardiography in all patients with suspected embolism, stroke etiology was classified as (i) large-artery atherosclerosis, (ii) cardioembolism, (iii) small-vessel occlusion, (iv) other determined etiology, or (v) undetermined etiology [13]. Out of group (iv), patients with dissection of brain-supplying arteries were identified.

Definition of SAP and treatment responsivity

Patients with (without) SAP are referred to as SAP^+ (SAP^-) patients. SAP was diagnosed according to the Center for Disease Control and Prevention criteria with clinical (lung auscultation and percussion, presence of fever, purulent tracheal secretion), microbiological (tracheal specimens, blood cultures), and chest x-ray findings [14]. The date of SAP onset was recorded. SAP occurring within the first 72 hours of NICU treatment was defined as early-onset pneumonia (EOP) [15]. The majority (75%) of EOP patients received initially an empirical antibiotic therapy with a combination of intravenously administered ceftriaxone (2000 mg per day) and metronidazole (1500 mg) to cover aerobic and anaerobic pathogens of suspected aspiration pneumonia [16, 17]. EOP responsivity to this initial antibiotic treatment was defined as a 50% decrease from maximum level of serum CRP within seven days together with normalization of body temperature. Accordingly, EOP patients were classified as responders (EOP-R) and non-responders (EOP-NR).

Statistical analysis

Receiver operating characteristic (ROC) curves were plotted (1) to describe the predictive value of age, NIHSS, and dysphagia score for development of SAP and to estimate the best cut-off values to discriminate SAP^+ and SAP^- patients; (2) to describe the predictive value of clinical (age, NIHSS, body temperature) and laboratory (leukocyte count, hematocrit, thrombozyte count, CRP, serum albumin) parameters for EOP treatment non-responsivity. Categorial data were analyzed by χ^2 test estimating relative risk (RR) factors for SAP development and for EOP treatment non-respon-

sivity with corresponding 95% confidence intervals (CI). Subsequently, a multivariable logistic regression model, controlling for possible confounding covariates, was fitted by forward stepwise selection (for inclusion, 5%; for exclusion, 10%) from the categorial variables found to be significant for SAP development (and EOP treatment non-responsivity, respectively) in the univariate analysis. All probability values are 2-sided, and the level of significance was set at $p < 0.05$. Statistical analyses were performed with SPSS 12.0 for Windows (SPSS Inc.).

Results

Study population and stroke characteristics

A total of 236 patients (124 men, mean age 67.6 ± 12.9 years; 112 women, 72.3 ± 13.1 years) with complete ischemic stroke were included. The mean duration of NICU treatment was 5.2 ± 5.9 days (range, 1–43 days). Hemispheric infarction was documented in 204 (86%) patients, with more than one hemispheric territory affected in 19 of them. Vertebrobasilar stroke was diagnosed in 32 (14%) patients, with simultaneous lesions in the brain stem and cerebellum in four, and combined vertebrobasilar and hemispheric stroke in three patients: one had acute infarctions in the brain stem and the posterior cerebral artery (PCA) territory, one in the cerebellum and the PCA territory, and one in each the brain stem, cerebellum, and PCA territory. Data analysis was performed for both possible classifications of the three patients with combined infra- and supratentorial infarctions, i.e. (1) assigning them according to the location of vertebrobasilar infarctions, and (2) assigning them as PCA infarction. In both cases, the same SAP risk factors were identified (Table 1); for further assessment, classification 1 was used since vertebrobasilar infarction accounted for the main part of patients impairment.

Epidemiology, microbiological findings and treatment response of SAP

SAP occurred in 51 (21.6%) of 236 patients with a mean latency from admission of 2.0 ± 2.9 days (range, 0–15 days). EOP developed in 40 (78%) SAP^+ patients. SAP^+ patients had larger mean age compared to SAP^- patients (76.1 ± 8.3 vs. 68.1 ± 13.8 years; *t*-test, $p < 0.001$), larger NIHSS (14.6 ± 5.8 vs. 7.6 ± 5.7; $p < 0.001$) and dysphagia score (2.0 ± 1.2 vs. 0.6 ± 1.0; $p < 0.001$).

Definite or presumptive pathogens were isolated in 13 SAP patients as shown in Table 2.

Prior to start of empirical antibiotic treatment with ceftriaxone and metronidazole in 30 EOP patients, pathogens could be verified in one of the 17 EOP-R patients (*Staphylococcus aureus*) and in two of the 13 EOP-NR patients (*Aspergillus fumigatus, Candida albicans*). Of the eight EOP-NR patients with vomiting and impaired vigilance, three died in hospital, two improved later without change of antibiotic drugs, whereas in the remaining three change to the following antibiotic medications was effective: fluconazole (n = 2), imipenem (n = 1), vancomycine (n = 1). Two of these eight EOP-NR patients fulfilled clinical and bronchoscopic criteria of pneumonitis due to gastric acid aspiration [16, 18].

Clinical predictors of SAP

NIHSS discriminated SAP^+ and SAP^- patients (ROC, area under curve [AUC]: 80.2%, $p < 0.001$), best at NIHSS ≥ 10 (sensitivity 82%, specificity 71%). NIHSS ≥ 5 had a 96% sensitivity but only a 35% specificity. If only SAP^+ patients who developed EOP were included, discrimination between EOP and SAP^- patients was clearer (AUC: 84.8%, $p < 0.001$), also best at NIHSS ≥ 10 (sensitivity 87%, specificity 71%). Dysphagia score discriminated SAP^+ and SAP^- patients (AUC: 80.2%, $p < 0.001$), with an 80% sensitivity and a 70% specificity at score ≥ 1, i.e. any presence of dysphagia. Dysphagia score discriminated even better between EOP and SAP^- patients (AUC: 84.5%, $p < 0.001$), with an 87% sensitivity and a 70% specificity at score ≥ 1, and an 82% sensitivity and an 86% specificity at score ≥ 2. Age discriminated SAP^+ and SAP^- patients to a less extent (AUC: 67.6%, $p < 0.001$), best at age ≥ 73 years (sensitivity 69%, specificity 60%).

Results of the univariate risk factor analysis are shown in Table 1 and Fig. 1.

Multivariable regression analysis yielded the following variables as independent SAP risk factors: dysphagia ($p < 0.001$; odds ratio [OR], 15.7; CI, 5.6–43.7), non-lacunar basal-ganglia infarction ($p = 0.002$; OR, 28.2; CI, 3.5–229.8), any other infection present on admission ($p = 0.004$; OR, 9.6; 95% CI, 2.1–44.4), and NIHSS ≥ 10 ($p = 0.046$; OR, 2.9; CI, 1.0–8.2). The logistic regression model reached a 76.5% sensitivity and an 88.0% specificity for individual SAP occurrence prediction (cutpoint, 0.5). If only SAP^+ patients with EOP were included in the analysis, the same independent risk factors were found, with a 90.0% sensitivity and an 88.0% specificity for individual EOP occurence prediction (cutpoint, 0.5).

If patients with infection other than pneumonia on admission were excluded from the analysis (SAP^+, n = 11; SAP^-, n = 5), multivariable regression analysis yielded the same independent SAP risk factors (except infection): dysphagia ($p < 0.001$; OR, 16.1; CI, 5.4–47.9), non-lacunar basal-ganglia infarction ($p = 0.002$; OR, 29.5; CI, 3.5–248), and NIHSS ≥ 10 ($p = 0.049$; OR, 3.1; CI, 1.0–9.5). In this case, the

Table 1 Demographic and clinical data in 236 patients with (SAP^+) and without (SAP^-) stroke-associated pneumonia who have been treated in a neurological intensive care unit

Patient characteristics	SAP^{+1} n = 51	SAP^{-1} n = 185	RR	95% CI	Significance[2]
Demographic data					
Age ≥ 73 years	35 (68.6)	75 (40.5)	2.51	1.47–4.27	**p < 0.001**
Male gender	24 (47.1)	100 (54.1)	0.80	0.49–1.31	p = 0.38
Diabetes	24 (36.9)	83 (40.3)	0.90	0.58–1.39	p = 0.63
Malignoma	4 (7.8)	4 (2.2)	2.43	1.16–5.07	**p = 0.047**
Smoker	7 (13.7)	46 (24.9)	0.54	0.26–1.13	p = 0.081
Heavy drinker	3 (5.9)	20 (10.8)	0.58	0.20–1.71	p = 0.29
Clinical findings *on admission*					
Infection other than SAP	11 (21.6)	5 (2.7)	3.78	2.45–5.83	**p < 0.001**
NIHSS ≥ 10	42 (82.4)	56 (30.3)	6.57	3.36–12.9	**p < 0.001**
Impaired vigilance	29 (56.9)	36 (19.5)	3.47	2.16–5.58	**p < 0.001**
Dysphagia	41 (80.4)	28 (15.1)	9.92	5.28–18.7	**p < 0.001**
Mechanical ventilation	4 (7.8)	3 (1.6)	2.78	1.40–5.55	**p = 0.020**
Ischemic stroke etiology					
Cardioembolism	29 (56.9)	69 (37.3)	1.86	1.14–3.03	**p = 0.012**
Large-artery atherosclerosis	8 (15.7)	26 (14.1)	1.11	0.57–2.14	p = 0.77
Small-vessel occlusion	2 (3.9)	52 (28.1)	0.14	0.03–0.55	**p < 0.001**
Dissection	1 (2.0)	6 (3.2)	0.65	0.10–4.08	p = 0.63
Ischemic stroke location					
MCA 1 (lacunar)	3 (5.9)	44 (23.8)	0.25	0.08–0.77	**p = 0.005**
MCA 2 (basal ganglia)[3]	5 (9.8)	3 (2.7)	3.10	1.17–5.62	**p = 0.004**
MCA 3 (subcortical)[3]	1 (2.0)	15 (8.1)	0.27	0.04–1.86	p = 0.122
MCA 4 (cortico-subcortic.)	25 (49.0)	66 (35.7)	1.53	0.95–2.48	p = 0.083
Right [vs. left] MCA 3, 4	12 [13] (48.0)	37 [44] (45.7)	1.07	0.54–2.13	p = 0.84
MCA I (< 33%)[3]	12 (23.5)	60 (32.4)	0.70	0.39–1.26	p = 0.22
MCA II (33–66%)	6 (11.8)	18 (9.7)	1.18	0.56–2.47	p = 0.67
MCA III (> 66%)	13 (25.5)	6 (6.5)	3.91	2.57–5.95	**p < 0.001**
ACA	1 (2.0)	6 (3.2)	0.65	0.10–4.08	p = 0.63
PCA	1 (2.0)	15 (8.1)	0.27	0.04–1.86	p = 0.12
Multiple hemispheric[4]	10 (19.6)	9 (4.9)	2.79	1.68–4.63	**p = 0.001**
Brain stem[5]	1 (2.0)	18 (9.7)	0.23	0.02–1.43	p = 0.071
Cerebellum[5]	1 (2.0)	8 (4.3)	0.50	0.08–3.25	p = 0.44
Multiple vertebrobasilar[5, 6]	3 (5.9)	1 (0.5)	3.62	1.95–6.73	**p = 0.009**

MCA indicates middle cerebral artery; ACA, anterior cerebral artery; PCA, posterior cerebral artery.
[1]Data given as total number (percentage proportion) of all stroke patients in that group; [2]χ^2 test (significant values of $p < 0.05$ in bold); [3]Non-lacunar infarctions; [4]More than one vascular hemispheric territory (MCA, ACA, PCA) affected; [5]One patient in the SAP^- group with additional infarction in the PCA territory; [6]Brain stem and cerebellum simultaneously affected by the ischemic lesion.

logistic regression model reached a 75.0% sensitivity and an 88.3% specificity for individual SAP occurrence prediction (cutpoint, 0.5).

Clinical predictors of non-responsitivity to initial antibiotic treatment in EOP

None of the following parameters discriminated EOP-NR and EOP-R: age (ROC, p = 0.075), NIHSS, body temperature, leukocyte count, hematocrit, thrombozyte count, CRP, and serum albumin (each $p > 0.3$). In the univariate categorial risk factor analysis, no impact of demographic findings, comorbidity, stroke etiology or stroke location was found. However, increased risk of EOP treatment non-responsivity was found in patients with vomiting (RR, 2.57; χ^2 test, $p < 0.05$) and vomiting in combination with impaired vigilance (RR, 2.76; $p < 0.05$), whereas dysphagia score ≥ 1 (RR, 0.37; $p < 0.05$) and score ≥ 2 (RR, 0.35; $p < 0.05$) were associated with decreased risk. Multivariable analysis yielded the finding of vomiting in combination with impaired vigilance (p = 0.019; OR, 7.47; CI, 1.40–39.8) as the only independent predictor, with a 62% sensitivity and an 82% specificity for individual prediction of EOP non-responsivity to initial treatment with ceftriaxone and metronidazole.

Discussion

Data obtained in this study show that dysphagia, non-lacunar basal-ganglia infarction, any infection other than pneumonia present on admission, and NIHSS ≥ 10 are independent initial clinical predictors of SAP occurrence, especially of EOP occurence. If the group of patients with infection on admission was excluded, the same independent predictors (except infection) were found. Failure of empirical antibacterial therapy of EOP is independently predicted by

Table 2 Microbiological findings in 51 patients with stroke-associated pneumonia

Pathogen verification	EOP-R n = 17	EOP-NR n = 13	EOP-O n = 10	LOP n = 11
Prior to start of antibiotic therapy				
Number of tested patients	8	7	5	6
No pathogen found	7[1]	5	5[3]	3
Staphylococcus aureus	1[2]	0	0	1
Listeria monocytogenes	0	0	0	1[2]
Klebsiella pneumon.+Haemophilus infl.	0	0	0	1
Candida albicans	0	1	0	0
Aspergillus fumigatus	0	1[2]	0	0
Under first antibiotic therapy				
Number of tested patients	9	6	3	4
No pathogen found	8[4]	4	1	2
Staphylococcus aureus	1	0	0	0
Aeromonas sobria	0	1[2]	0	0
Escherichia coli	0	0	0	1
Klebsiella pneumoniae	0	0	0	1
Klebsiella oxytoca+Candida albicans	0	0	1	0
Candida albicans	0	1	0	0
Candida glabrata	0	0	1	0

EOP-R indicates early-onset pneumonia responsive to initial antibiotic therapy with ceftriaxone and metronidazole; EOP-NR, EOP non-responsive to initial antibiotic therapy with ceftriaxone and metronidazole; EOP-O, EOP initially treated with other antibiotics; LOP, late-onset pneumonia.
[1]Two patients with ventilator-associated pneumonia.
[2]One patient with ventilator-associated pneumonia.
[3]Two patients with verification of germs unlikely to have caused pneumonia (coagulase-negative staphylococci).
[4]Four patients with verification of germs unlikely to have caused pneumonia (two with coagulase-negative staphylococci, two with enterococci).

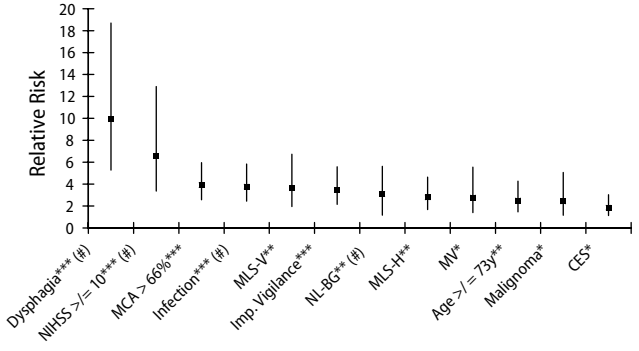

Fig. 1 Factors with significantly increased relative risk for development of SAP. Vertical lines refer to 95% CIs. NIHSS indicates National Institute of Health Stroke Scale; MCA > 66%, infarction affecting more than 66% of territory of the middle cerebal artery; MLS-V, multiple location stroke, vertebrobasilar; NL-BG, non-lacunar basal-ganglia infarction; MLS-H, multiple location stroke, hemispheric; MV, mechanical ventilation; CES, cardioembolic stroke. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; (#) independent risk factors

initial vomiting, especially if associated with impaired vigilance.

The studied group of stroke patients had a mean age by 2–5 years lower compared to the mean age at first-ever stroke estimated in community-based studies in Southern Germany and Switzerland [19, 20]. This may be due to two reasons: (i) very old patients with ischemic stroke may have been more often referred to other hospitals without a Stroke Unit compared to younger stroke patients [20], even though we do not operate an age limit for Stroke Unit access; (ii) the higher prevalence of cardiovascular risk factors, especially of hypertension, in the north-eastern as compared to the south-western German population may have caused a shift toward younger age at onset of ischemic stroke in our study population [19, 21].

The overall SAP incidence of 21.6% in our study population and the spectrum of pathogens is in line with previously reported findings in patients treated on an NICU [1, 22]. Considering the various SAP risk factors found in previous studies, the present study aimed to determine those clinical risk factors that independently predict SAP and that, in principle, are available in all stroke patients on day of hospital admission. The earlier reported risk factors dysphagia [1, 3], higher NIHSS [6], and non-lacunar basal-ganglia infarction [23] were identified here as independent SAP predictors. In concordance with previous reports [1–3, 5, 6], we also identified age, large MCA infarction, multiple hemispheric or vertebrobasilar infarction, mechanical ventilation on admission, and impaired vigilance as predictors of SAP, whereas small vessel occlusion was associated with decreased SAP risk. These risk factors, however, were not found to be independent in this study. In contrast to previous reports [2, 6], we did not find an impact of male gender or diabetes. Moreover, we did not find any influence by lateralization of MCA infarction, which agrees with results of a recent animal study [24]. Compared to a 97% sensitivity and 46% specificity in SAP prediction in a similar stroke population [1], in

the present study a sensitivity of 76% (EOP: 90%) and a markedly higher specificity of 88% was achieved by the determined independent risk factors.

Pneumonia is the leading cause of death in the postacute phase of stroke [2]. Since dysphagia had been found as a major risk factor for SAP, leading to aspiration pneumonia in about one third of dysphagic patients [25], early diagnosis and treatment of dysphagia were recommended as primary goals to prevent SAP [26]. However, conservative measures, such as feeding with nasogastric tube and other forms of dietary modification, provided only limited protection against SAP [27, 28]. This supports the idea that other factors such as stroke-induced alteration of systemic immune response might play a relevant role. Results of animal studies suggested that stroke-induced immunodeficiency promotes bacterial infections [29], especially aspiration pneumonia [30], and that early preventive antibacterial treatment improves the outcome after stroke [7]. A subsequent study on early preventive antibacterial treatment in acute stroke patients, however, failed to show a benefit [9]. This discrepancy might have been caused by inclusion also of patients with low risk of developing infection. Whereas artificial MCA occlusion in the animal model always led to large infarctions [7], in the human study a relevant number of patients with small infarction had been included [9]. Moreover, in the human stroke study inclusion was defined by NIHSS ≥ 5 which is a less specific predictor of SAP than NIHSS ≥ 10, according to the results of the present study.

In a post-hoc analysis, we studied risk factors of EOP non-responsivity to initial standard antibiotic therapy. The only independent risk factor of treatment non-responsivity was initial vomiting, especially if associated with impaired vigilance (8 [62%] EOP-NR, 3 [18%] EOP-NR patients). If these conditions co-occur, the possibility of gastric-acid aspiration pneumonitis needs to be considered [16]. However, only in two EOP-NR patients aspiration pneumonitis was diagnosed. Even though it can not be excluded that we missed the diagnosis of mild aspiration pneumonitis in some cases, our findings imply that initial vomiting in stroke patients might be associated with different pathogens in EOP-NR, compared to EOP-R. In EOP-R patients only bacterial pathogens could be verified but fungal pathogens in EOP-NR patients. Antifungal therapy led to improvement if applied in EOP-NR patients. Despite caution in data interpretation is advisable in view of the low rate of pathogen verification, findings suggest that stroke patients with initial vomiting and impaired vigilance should be set on a broader microbiological monitoring, including search for fungal pathogens at once after admission.

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