

Age- and sex-related differences in community-acquired pneumonia at presentation to the emergency department: a retrospective cohort study

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Background and importance Because of its associated high morbidity and mortality, early identification and treatment of community-acquired pneumonia (CAP) are essential.

Objectives To investigate age- and sex-related differences in clinical symptoms, radiologic findings and outcomes in patients presenting to the emergency department (ED) with CAP.

Design Retrospective cohort study.

Setting and participants Patients admitted to one Swiss ED with radiologically confirmed CAP between 1 January 2017 and 31 December 2018.

Outcome measures and analysis Primary aim was to evaluate differences in clinical and radiologic presentation of men vs. women and patients >65 years vs. <65 years with CAP. Secondary outcomes were age- and sex-related differences in terms of Pneumonia Severity Index (PSI) risk class, need for ICU referral, mechanical ventilation, in-hospital mortality, 30-day readmission and 180-day pneumonia recurrence.

Main results In total 467 patients with CAP were included. 211 were women (45%). 317 were ≥65 years (68%), of which 145 were women (46%). Older patients less commonly reported chest pain (13 vs. 27%; effect size 14%; 95% CI, 0.07–0.23), fever (39 vs. 53%, effect size 14%; 95% CI, 0.05–0.24), chills (6 vs. 20%; effect size 14%; 95% CI, 0.08–0.214), cough (44 vs. 57%; effect size 13%; 95% CI, 0.03–0.22), headache (5 vs. 15%, effect size 10%,

95% CI, 0.04–0.17) and myalgias (5 vs. 19%; effect size 14%; 95% CI, 0.07–0.21). However, 85% of patients with no symptoms were ≥65 years. PSI was lower in women [95 (SD 31) vs. 104 (SD 31); 95% CI, –14.44 to 2.35] and sputum was more common in men (32 vs. 22%; effect size 10%; 95% CI, –0.18 to –0.02). Raw mortality was higher in elderly patients [14 vs. 3%; odds ratio (OR), 4.67; 95% CI, 1.81–12.05], whereas it was similar in men and women (11 vs. 10%; OR, 1.22; 95% CI, 0.67–2.23).

Conclusion Patients, less than 65 years with CAP presenting to the ED had significantly more typical symptoms such as chest pain, fever, chills, cough, headache and myalgias than those being above 65 years. No relevant differences between men and women were found in clinical presentation, except for PSI on admission, and radiologic findings and neither age nor sex was a predictor for mortality in CAP. *European Journal of Emergency Medicine* XXX: 000–000 Copyright © 2022 Wolters Kluwer Health, Inc. All rights reserved.

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Keywords: age-related differences, community-acquired pneumonia, elderly, emergency department, sex-related differences

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Introduction

Community-acquired pneumonia (CAP) is one of the leading causes of morbidity and mortality worldwide and yet evidence regarding identification or management of patients with predisposition or risk factors remains scarce [1]. In the USA, the mortality of patients having been hospitalized for CAP was 30.6% 1 year after discharge [2]. The diagnosis of CAP requires a combination of compatible symptoms and clinical findings or radiologic evidence of apulmonary infiltrate [1,3]. Differences in the clinical presentation of CAP, especially in elderly or immunocompromised patients, might complicate early diagnosis and treatment. In the elderly population, commonly defined

as individuals aged older than 65 years, atypical clinical presentation of CAP is often associated with fewer symptoms [4–6] and different treatment approaches are discussed [7]. This is even more important in view of the continuously rising number of elderly patients admitted to the emergency department (ED): in a retrospective analysis, the number of patients aged ≥65 years rose from 33 to 37.8% between 2015 and 2018 [8]. The severity assessment tools Confusion, Urea, Respiratory rate, Blood pressure and Pneumonia Severity Index (PSI) were both associated with mortality in elderly patients [9]. In terms of sex-related differences, evidence on CAP is even rarer. Several studies report age- and sex-related

differences in CAP: male sex was found to be associated with perioperative pneumonia in geriatric patients with hip fractures [10]. Furthermore, elderly men hospitalized for CAP showed higher mortality independent of age, residency before admission, comorbidities and microbiologic etiology [11]. There are several studies reporting an association of male sex with poor outcomes in pneumonia [11–13]. In terms of microbial pathogens, the incidence of CAP due to infection with *Legionella pneumophila* was 10 times increased in men and the male sex was found to be associated with pulmonary infections with *Chlamydia* spp. in Spain [14]. Another study investigating atypical causative agents of CAP in inpatients also identified an association with the male sex [15]. Contrary to these findings, no significant sex difference was found in terms of outcome or resource utilization in critically ill patients with pneumonia on ICU treatment [16].

In emergency medicine, evidence on age- or sex-related differences in patients with CAP is rare. Therefore, the primary aim of this study was to evaluate differences in clinical and radiologic presentation of men, women, elderly and younger patients presenting to the ED with CAP.

Materials and methods

Study design and setting

This retrospective cohort study was performed at the ED of the Buegerspital Solothurn, a secondary care center, between 1 January 2017 and 31 December 2018. Data until 30 June 2019 were included to evaluate the 30-day readmission and 180-day pneumonia recurrence rate defined as readmission to the same hospital till day 180 after discharge.

Objectives

The primary aim of the study was to investigate differences in clinical and radiological presentation of patients with CAP in terms of age and sex. Secondary outcomes were age- and sex-related differences regarding disease severity expressed by PSI risk class, need for ICU treatment, need for mechanical ventilation, in-hospital mortality, 30-day readmission and 180-day pneumonia recurrence rate.

Patients

All patients admitted to the ED of the Buegerspital Solothurn, a secondary care center, between 1 January 2017 and 31 December 2018 were screened for CAP. CAP was defined as an acute infection of the pulmonary parenchyma acquired outside the hospital with a radiologically demonstrated presence of an infiltrate and presence of compatible clinical presentation [17]. CAP was identified by screening the electronic patients' chart and following verification by the study physicians. Sex was defined as the binary biologic term male or female as given in the respective literature [18,19]. However, for the sake of

readability, the terms men/women and male/female will be used interchangeably throughout the article. Patients younger than 18 years and those who written or verbally withdrew consent for use of their data for scientific purposes were excluded from the study.

Measurements

Of all patients data on age, sex, diagnosis of CAP, medication on admission and PSI were gathered by chart review as was recently published [20,21]. Diagnosis of CAP was made according to current joint guidelines from Germany, Austria and Switzerland [22]. Patients were classified as elderly when aged ≥ 65 years [4,5,8]. Outcome measures included the need for ICU admission and/or mechanical ventilation, 30-day readmission, 180-day pneumonia recurrence and in-hospital mortality during the initial hospitalization. In addition, data on clinical symptoms at presentation, vital signs in the ED, laboratory parameters (i.e. blood count, C-reactive protein levels, procalcitonin, serum creatinine and arterial blood gas analysis), supplemental oxygen use as well as radiological findings were obtained by chart review. Symptoms were classified as chest pain, fever, chills, cough, sputum, dyspnea, headache and myalgia [3]. If no information on symptoms was documented, symptoms were classified as 'not present'. Fever was defined as a measured tympanic temperature of ≥ 38.5 °C. Radiologic diagnostics included conventional X-rays as well as computed tomography of the chest and findings were classified into the presence of pleural effusion, presence of bilateral infiltrates and the number of affected lobes. All charts were screened and reviewed by three persons (C.G., R.G. and S.R.). The study protocol was reviewed and approved by the local ethics committee 'Ethikkommission Nordwest- und Zentralschweiz' (project-ID 2021-00442).

Statistical analysis

After completion of data collection, data were cleaned and outliers [$>95\%$ confidence interval (CI)] were reconfirmed or corrected. Data were exported to a statistical software package (SPSS for Macintosh, version 28; SPSS Inc; Chicago, Illinois, USA) for analysis. Continuous data are presented as mean and SD or median and interquartile ranges. Categorical data are presented as absolute counts and percentages. Between-group comparisons of continuous variables were performed using Mann–Whitney-U test. Categorical variables were compared using the χ^2 test or Fisher's exact test.

Results

Between 1 January 2017 and 31 December 2018 a total of 19,948 ED consultations with measurements of serum sodium and potassium were reported. In total 467 patients fulfilled the criteria for CAP of which 256 were men (55%) and 211 were women (45%). The mean age was 70 years (SD 18). Table 1 shows an overview of the baseline characteristics of all patients with CAP.

Comparison between elderly and younger patients with community-acquired pneumonia

In total, 317 patients were ≥ 65 years old (68%), of which 145 were women (46%). Mean PSI was significantly higher in patients ≥ 65 years [72 (SD 30) vs. 109 (SD 31); 95% CI, -43.52 to 32.18] and so was PSI risk class [2 (SD 1.1) vs. 4 (SD 0.8); 95% CI, -1.99 to 1.61]. History of cerebrovascular disease and presence of altered mental status on admission to the ED were significantly more common in elderly patients, who were more often nursing home residents. Details are given in Table 2.

Regarding symptoms, chest pain on presentation was significantly less commonly reported in patients older than 65 years (13 vs. 27%; effect size 14%; 95% CI, 0.07–0.23) and so was fever (39 vs. 53%; effect size 14%; 95% CI, 0.05–0.24), chills (6 vs. 20%; effect size 14%; 95% CI, 0.08–0.214), cough (44 vs. 57%; effect size 13%; 95% CI, 0.03–0.22), headache (5 vs. 15%; effect size 10%; 95% CI, 0.04–0.17) and myalgias (5 vs. 19%; effect size 14%; 95% CI, 0.07–0.21). No difference for the presence of dyspnea and sputum on presentation to the ED was found between age groups. Details on the presence of symptoms in the investigated age groups are given in Table 3 and the distribution of symptoms in elderly and younger patients is depicted in Fig. 1. The need for supplemental oxygen therapy during ED stay was significantly more common in elderly patients (21 vs. 8%; $P=0.006$).

In terms of radiologic findings, no age-related difference was seen concerning the presence of pleural effusion at presentation to the ED [17 vs. 22%; odds ratio (OR), 1.42; 95% CI, 0.86–2.35]. Bilateral pneumonia was similarly common in both groups (17 vs. 20%; OR, 1.22; 95% CI, 0.73–2.03).

Table 1 Baseline characteristics of all patients with CAP

Parameter	N	Percent
Chest pain	81	17
Fever	203	43
Chills	48	10
Cough	225	48
Sputum	128	27
Dyspnea	140	30
Headache	40	9
Myalgia	46	10
PSI score	100 (± 31)	
PSI risk class		
1	53	11
2	71	15
3	87	19
4	178	38
5	78	17
ICU/IMC admission	71	15
Noninvasive ventilation	10	2
Invasive ventilation	8	2
30-day readmission	57	12
180-day pneumonia recurrence	52	11
In-hospital mortality	49	10

PSI, Pneumonia Severity Index; IMC, intermediate care unit.

Elderly patients had significantly higher SBP while lower DBP, lower heart rate, lower body temperature as well as lower oxygen saturation. Hemoglobin was significantly lower, whereas serum creatinine, urea, potassium as well as sodium were significantly higher in patients 65 years or older. Table 4 provides details on the differences in vital signs and laboratory parameters between age groups.

Uncorrected mortality was higher in elderly patients (14 vs. 3%; OR, 4.67; 95% CI, 1.81–12.05). No difference was found concerning the proportions of intermediate care unit (IMC)/ICU treatment (17 vs. 14%; OR, 0.79; 95% CI, 0.47–1.34). Moreover, need for noninvasive and invasive ventilation (5 vs. 3%; $P=0.55$) was similar between groups. In addition, no difference in 30-day readmission (14 vs. 11%; OR, 0.79; 95% CI, 0.44–1.40) and 180-day pneumonia recurrence rates (10 vs. 12%; OR, 1.19; 95% CI, 0.63–2.24) was found.

Variations in community-acquired pneumonia compared between men and women

There was no difference in age between men and women with CAP (70 vs. 70 years, $P=0.68$). PSI score was significantly lower in women than in men: 95 (SD 31) and 104 (SD 31), 95% CI -14.44 to -2.35. No difference was found for the components of the PSI score between men and women. Table 2 gives an overview on the PSI risk classes as well as the components of the PSI stratified for patients' sex.

Concerning clinical presentation and symptoms, there was no significant sex-related difference in terms of chest pain (21 vs. 14%; effect size 7%; 95% CI, 0.01–1.34), fever (40 vs. 46%; effect size 6; 95% CI, -0.15 to -0.03), chills (12 vs. 9%; effect size 3%; 95% CI, -0.03 to -0.09), cough (50 vs. 46%; effect size 4%; 95% CI, -0.05 to -0.13), dyspnea (32 vs. 28%; effect size 4%; 95% CI, -0.04 to -0.124), headache (9 vs. 8%; effect size 1%; 95% CI -0.04 to -0.06) or myalgia (12 vs. 8%; effect size 5%; 95% CI, -0.01 to -0.1). The presence of sputum on admission to the ED was significantly less commonly reported by women than by men (22 vs. 32%; effect size 10%; 95% CI, -0.18 to -0.02). There was no difference in clinical presentation between men and women, except for the presence of sputum on admission to the ED, which was more common in men than in women (see Table 3). The distribution of symptoms is depicted Fig. 2.

The analysis of radiologic findings showed that the presence of pleural effusion at presentation to the ED was similar in women and men (23 vs. 18%; OR, 0.76; 95% CI, 0.49–1.20) and there was no difference in the presence of bilateral pneumonia (17 vs. 20%; OR, 1.28; 95% CI, 0.80–2.06).

Women had significantly higher platelets, lower urea as well as serum potassium levels on admission. Table 4 gives an overview of the vital signs as well as laboratory parameters of patients with CAP stratified for sex.

Table 2 Pneumonia Severity Index score, PSI risk classes and its components stratified for sex and age groups

Parameter	Sex			Age			
	Women (N=211)	Men (N=256)	P value	<65 years (N=150)	≥65 years (N=317)	P value	
PSI	95 ± 31	104 ± 31	0.01	72 ± 30	109 ± 31	<0.01	
PSI risk class	1	25 (12%)	28 (11%)	0.09	53 (35%)	0 (0%)	<0.01
	2	42 (20%)	29 (11%)		52 (35%)	19 (6%)	
	3	40 (19%)	47 (18%)		22 (15%)	65 (21%)	
	4	71 (34%)	107 (42%)		21 (14%)	157 (50%)	
	5	33 (16%)	45 (18%)		2 (1%)	76 (24%)	
Hematocrit <30%	22 (10%)	23 (9%)	0.638	7 (5%)	38 (12%)	0.01	
Glucose >14 mmol/L	5 (2%)	8 (3%)	0.78	2 (1%)	11 (0.5%)	0.24	
Urea >11 mmol/L	48 (23%)	56 (22%)	0.824	9 (6%)	95 (30%)	<0.01	
Sodium <130 mmol/L	13 (6%)	12 (5%)	0.539	10 (7%)	15 (5%)	0.39	
Nursing home resident	55 (26%)	49 (19%)	0.075	8 (5%)	96 (30%)	<0.01	
Neoplastic disease	41 (19%)	60 (23%)	0.311	25 (17%)	76 (24%)	0.09	
Cerebrovascular disease	19 (9%)	34 (13%)	0.187	4 (3%)	49 (15%)	<0.01	
Temperature <35 or >39.9 °C	2 (1%)	2 (1%)	1.0	3 (2%)	1 (0.5%)	0.1	
Altered mental status	18 (9%)	29 (11%)	0.356	5 (3%)	42 (13%)	<0.01	
SBP <90 mmHg	4 (2%)	6 (2%)	1.0	3 (2%)	7 (2%)	1.0	
RR >29/min	13 (6%)	19 (7%)	0.714	6 (4%)	26 (8%)	0.12	
HR >124/min	16 (8%)	13 (5%)	0.336	8 (5%)	21 (7%)	0.68	
pH <7.35	8 (4%)	9 (4%)	0.798	4 (3%)	13 (4%)	0.58	
pO ₂ <8 kPa	20 (10%)	22 (9%)	0.699	14 (9%)	28 (9%)	0.67	

HR, heart rate; PSI, Pneumonia Severity Index; RR, respiratory rate.

Table 3 Comparison of symptoms between men and women and different age groups

Symptom	Symptom present	Sex			Age		
		Women (N=211)	Men (N=256)	Effect size (95% CI)	<65 years (N=150)	≥65 years (N=317)	Effect size (95% CI)
Chest pain	0	167	219	6% (-0.01 to 0.13)	109	277	14% (0.07-0.23)
	1	44	37		41	40	
Fever	0	126	138	6% (-0.15 to 0.03)	70	194	14% (0.05-0.24)
	1	85	118		80	123	
Chills	0	186	233	3% (-0.03-0.09)	120	299	14% (0.08-0.21)
	1	25	23		30	18	
Cough	0	105	137	4% (-0.05 to 0.13)	65	177	13% (0.03-0.22)
	1	106	119		85	140	
Sputum	0	165	174	10% (-0.18 to 0.02)	102	237	7% (-0.02-0.16)
	1	46	82		48	80	
Dyspnea	0	143	184	4% (-0.04 to 0.12)	110	217	5% (-0.13 to 0.04)
	1	68	72		40	100	
Headache	0	192	235	1% (-0.04 to 0.06)	127	300	10% (0.04-0.17)
	1	19	21		23	17	
Myalgia	0	185	236	5% (-0.01 to 0.1)	121	300	14% (0.07-0.21)
	1	26	20		29	17	

CI, confidence interval.

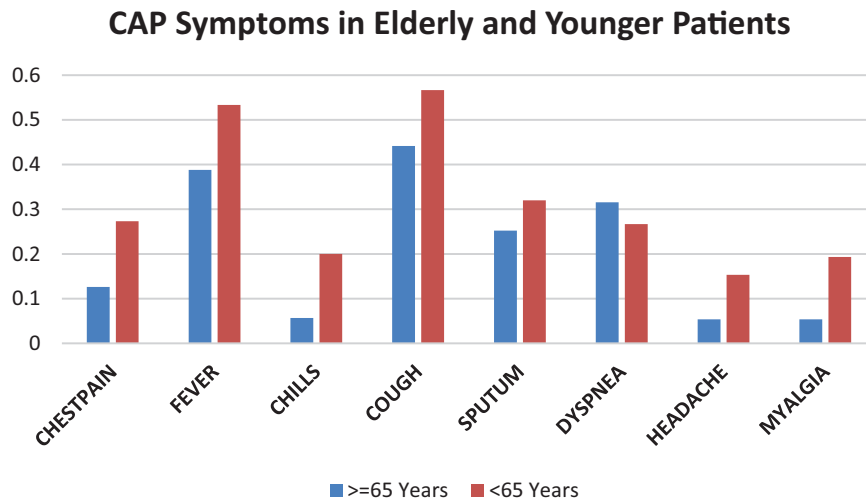
No difference in crude mortality could be found between women (10%) and men (11%), OR, 1.22; 95% CI, 0.67-2.23. Moreover, there was no difference with respect to IMC or ICU treatment (13 vs. 17%; OR, 1.41; 95% CI, 0.84-2.38), 30-day hospital readmission (13 vs. 12%; OR, 0.91; 95% CI, 0.52-1.58) or 180-day pneumonia recurrence (11 vs. 11%; OR, 0.96; 95% CI, 0.54-1.71). Also, the need for noninvasive or invasive ventilation was similar between women and men (3 vs. 4%; $P=0.15$).

Overall, 88 patients had no reported typical symptoms of CAP at all (19%) of which 47 were men (53%) and 41 were women (47%). Of the patients without typical symptoms, 75 patients were ≥65 years old (85%).

Discussion

In this retrospective study in patients presenting to the ED with CAP, age- and sex-related characteristics in symptoms, clinical and radiologic findings were investigated. In terms of clinical presentation, elderly patients reported significantly less symptoms typical for pneumonia, such as chest pain, fever, chills, cough, headache and myalgias. Elderly patients showed significantly higher PSI scores, PSI risk classes and altered mental status on admission and presented with lower heart rates, body temperature and oxygen saturation. The finding that clinical presentation of CAP in elderly patients differs relevantly from younger patients is consistent with previous studies [4-6], however, the high level of significance

Fig. 1



Distribution of CAP Symptoms in Elderly and Younger Patients. CAP, community-acquired pneumonia.

Table 4 Vital signs and laboratory parameters stratified for sex and age, respectively

Parameter	Sex			Age		
	Women (N=211)	Men (N=256)	p-value	<65 years (N=150)	≥65 years (N=317)	P value
SBP (mmHg)	132±25	133±25	0.67	128±23	135±26	0.01
DBP (mmHg)	77±16	79±15	0.31	82±15	77±16	<0.01
Heart rate (beats/min)	93±21	92±21	0.67	98±20	91±21	<0.01
SpO ₂ (%)	93±6.6	92±6.5	0.77	95±6.2	92±7.5	<0.01
Body temperature (°C)	37.3 (36.5–38)	37.2 (36.4–38)	0.21	37.2 (36.6–38.2)	36.7 (36.4–38)	0.03
Hemoglobin (g/l)	121±28	127±27	<0.01	129±26	123±28	<0.01
Leucocytes (G/l)	11.1±5.2	10.6±5.3	0.45	11.0±5	10.8±5.4	0.48
Blood platelets (G/l)	233±110	214±111	<0.01	228±109	221±96	0.77
C-reactive protein level (mg/l)	123±97	126±96	0.39	130±96	122±97	0.49
Serum creatinine (umol/l)	96±87	113±87	<0.01	93±87	112±68	<0.01
eGFR (ml/min)	67±31	71±30	0.10	90±29	59±26	<0.01
Urea (mmol/l)	8.2±12	9.4±11.7	0.02	5.6±11	10.4±14	<0.01
Serum potassium (mmol/l)	3.9±0.6	4.0±0.5	<0.01	3.9±0.6	4.0±0.6	<0.01
Serum sodium (mmol/l)	136±4.8	137±4.8	0.30	135±4.8	137±4.8	<0.01

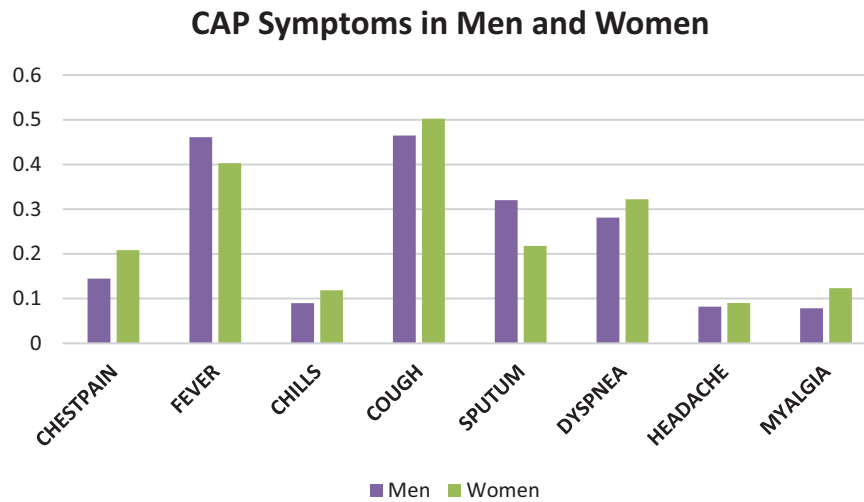
BP, blood pressure; eGFR, estimated glomerular filtration rate; SpO₂, peripheral oxygen saturation.

for differences between elderly and younger patients in so many CAP-specific symptoms is rather new and striking. This finding is even further emphasized by the fact that in this analysis up to 85% of all patients without reported CAP-typical symptoms were ≥65 years old. Because the global influence on morbidity and mortality of CAP is substantial [1] and the elderly patient population making up a growing number of ED consultations [8], measures to speed up early identification of CAP in this particular patient group and initiate treatment right away are to be welcomed. Especially, the absence of CAP key symptoms, such as cough and fever might complicate early diagnosis in elderly patients. In terms of laboratory findings, lower hemoglobin, higher serum creatinine, urea, potassium and sodium were detected in the elderly compared to younger patients, probably associated with the higher burden of disease in the elderly. Interestingly, no age-related differences were detected

in terms of radiologic findings, such as the presence of pleural effusion, distribution of infiltrates or affected lobes, suggesting a more liberal approach to radiologic diagnostics in the elderly to identify CAP even though clinical presentation might be atypical or indistinct. PSI score and risk class seem to be a helpful tool to identify patients at risk since elderly patients with CAP showed significantly higher values. An association of PSI with mortality was already found in the elderly [9]. In view of all these findings, pneumonia prevention appears to be essential in elderly patients. Only recently, several prevention measures were suggested, consisting of dysphagia prevention, lifestyle modifications, such as cessation of alcohol or tobacco consumption, respiratory physiotherapy and professional teeth maintaining with particular focus on adequate oral hygiene [23].

Regarding sex-related differences, PSI was significantly lower in women and they reported significantly

Fig. 2



Distribution of CAP Symptoms in Men and Women. CAP, community-acquired pneumonia.

less sputum on admission. No sex-related difference in crude mortality was found and outcome measures such as need for IMC/ICU admission, 30-day hospital readmission and 180-day pneumonia recurrence were comparable between men and women. Importantly, it can be assumed on basis of these findings that a nondifferentiated diagnostic and treatment approach for men and women is justified. Interestingly, in a mouse model, Pittet *et al.* [24] found that lung bacterial cleaning was impaired and mortality increased in male mice after traumatic brain injury. When injecting male mice with estrogen, lung bacterial clearance was restored, suggesting a salutary effect of estrogen after trauma [24]. This suggested protective effect of estrogens might be considered when investigating sex-related differences in pulmonary infection in the future.

Limitations

Due to the retrospective design of the study, information that was not assessed on admission could not be retrieved for further investigation including potentially severe clinical findings not reported in the electronic patients' chart. For reasons of simplicity, missing information was considered to be within the normal range, which leaves room for misinterpretation. However, due to obligatory documentation requirements in medicine, relevant findings are likely to have been documented appropriately. No follow-up after hospitalization was conducted. We cannot exclude, that patients without an undocumented diagnosis of CAP were missed during the screening. The current data stem from a single center in central Europe and the external validity of the findings is limited for other geographic areas. In terms of laboratory findings such as creatinine and urea, there was no correction for weight-related differences.

Conclusion

In conclusion, patients less than 65 years with CAP presenting to the ED had significantly more typical clinical symptoms, such as chest pain, fever, chills, cough, headache and myalgias than those over 65 years. No relevant differences between men and women were found in clinical presentation and radiologic findings. In this sample, neither age nor sex was a predictor for mortality in CAP.

Acknowledgements

The study protocol was reviewed and approved by the local ethics committee "Ethikkommission Nordwest- und Zentralschweiz" (project-ID 2021-00442).

The need for informed consent was waived by the ethics committee and an exception was granted due to the large patient number and the retrospective design of the study.

All authors contributed in the research and manuscript preparation. S.R.: conceptualization, methodology, investigation, data analysis, manuscript draft. C.G.: investigation, database management, critically reviewed manuscript. R.G.: investigation, database management, critically reviewed manuscript. A.K.E.: investigation, critically reviewed manuscript. G.L.: conceptualization, methodology, investigation, data analysis, manuscript draft.

The data that support the findings of this study are not publicly available because they stem from patient chart reviews but are available from S.R. on request.

Conflicts of interest

There are no conflicts of interest.

References

- Aliberti S, Dela Cruz CS, Amati F, Sotgiu G, Restrepo MI. Community-acquired pneumonia. *Lancet* 2021; **398**:906–919.

- 2 Ramirez JA, Wiemken TL, Peyrani P, Arnold FW, Kelley R, Mattingly WA, *et al.*; University of Louisville Pneumonia Study Group. Adults hospitalized with pneumonia in the United States: incidence, epidemiology, and mortality. *Clin Infect Dis* 2017; **65**:1806–1812.
- 3 Ebell MH, Chupp H, Cai X, Bentivegna M, Kearney M. Accuracy of signs and symptoms for the diagnosis of community-acquired pneumonia: a meta-analysis. *Acad Emerg Med* 2020; **27**:541–553.
- 4 Niederman MS, Ahmed QA. Community-acquired pneumonia in elderly patients. *Clin Geriatr Med* 2003; **19**:101–120.
- 5 Kobashi Y, Okimoto N, Matsushima T, Soejima R. Clinical analysis of community-acquired pneumonia in the elderly. *Intern Med* 2001; **40**:703–707.
- 6 Metlay JP, Schulz R, Li YH, Singer DE, Marrie TJ, Coley CM, *et al.* Influence of age on symptoms at presentation in patients with community-acquired pneumonia. *Arch Intern Med* 1997; **157**:1453–1459.
- 7 Lieberman D, Lieberman D. Community-acquired pneumonia in the elderly: a practical guide to treatment. *Drugs Aging* 2000; **17**:93–105.
- 8 Woitok BK, Ravioli S, Funk G-C, Lindner G. Characteristics of very elderly patients in the emergency department – a retrospective analysis. *Am J Emerg Med* 2021; **46**:200–203.
- 9 Thiem U, Niklaus D, Sehlhoff B, Stücker C, Heppner HJ, Endres HG, Pientka L. C-reactive protein, severity of pneumonia and mortality in elderly, hospitalised patients with community-acquired pneumonia. *Age Ageing* 2009; **38**:693–697.
- 10 Wang X, Dai L, Zhang Y, Lv Y. Gender and low albumin and oxygen levels are risk factors for perioperative pneumonia in geriatric hip fracture patients. *Clin Interv Aging* 2020; **15**:419–424.
- 11 Kaplan V, Angus DC, Griffin MF, Clermont G, Scott Watson R, Linde-Zwirble WT. Hospitalized community-acquired pneumonia in the elderly: age- and sex-related patterns of care and outcome in the United States. *Am J Respir Crit Care Med* 2002; **165**:766–772.
- 12 Marini S, Morotti A, Lena UK, Goldstein JN, Greenberg SM, Rosand J, Anderson CD. Men experience higher risk of pneumonia and death after intracerebral hemorrhage. *Neurocrit Care* 2018; **28**:77–82.
- 13 Alsawas M, Wang Z, Murad MH, Yousufuddin M. Gender disparities among hospitalised patients with acute myocardial infarction, acute decompensated heart failure or pneumonia: retrospective cohort study. *BMJ Open* 2019; **9**:e022782.
- 14 Gutiérrez F, Masiá M, Mirete C, Soldán B, Rodríguez JC, Padilla S, *et al.* The influence of age and gender on the population-based incidence of community-acquired pneumonia caused by different microbial pathogens. *J Infect* 2006; **53**:166–174.
- 15 Raeven VM, Spoorenberg SM, Boersma WG, van de Garde EM, Cannegieter SC, Voorn GP, *et al.*; Alkmaar Study Group; Ovidius Study Group. Atypical aetiology in patients hospitalised with community-acquired pneumonia is associated with age, gender and season; a data-analysis on four Dutch cohorts. *BMC Infect Dis* 2016; **16**:299.
- 16 Caceres F, Welch VL, Kett DH, Scerpella EG, Peyrani P, Ford KD, Ramirez JA; Impact-Hap Study Group. Absence of gender-based differences in outcome of patients with hospital-acquired pneumonia. *J Womens Health (Larchmt)* 2013; **22**:1069–1075.
- 17 Metlay JP, Waterer GW, Long AC, Anzueto A, Brozek J, Crothers K, *et al.* Diagnosis and treatment of adults with community-acquired pneumonia. An official clinical practice guideline of the American Thoracic Society and Infectious Diseases Society of America. *Am J Respir Crit Care Med* 2019; **200**:e45–e67.
- 18 Bloom B. European Journal of Emergency Medicine position on reporting sex and gender. *Eur J Emerg Med* 2021; **28**:330.
- 19 Dessie A, Alvarez A, Lewiss RE. Standardizing terminology in academic medical journals: understanding sex and gender. *Eur J Emerg Med* 2021; **28**:331–332.
- 20 Ravioli S, Gygli R, Funk GC, Exadaktylos A, Lindner G. Prevalence and impact on outcome of sodium and potassium disorders in patients with community-acquired pneumonia: a retrospective analysis. *Eur J Intern Med* 2021; **85**:63–67.
- 21 Fine MJ, Auble TE, Yealy DM, Hanusa BH, Weissfeld LA, Singer DE, *et al.* A prediction rule to identify low-risk patients with community-acquired pneumonia. *N Engl J Med* 1997; **336**:243–250.
- 22 Ewig S, Höffken G, Kern WV, Rohde G, Flick H, Krause R, *et al.* Management of adult community-acquired pneumonia and prevention – update 2016 published by the German Respiratory Society, the Paul-Ehrlich-Society for Chemotherapy, the German Society for Infectious Diseases, the Competence Network CAPNETZ, the Austrian Respiratory Society the Austrian Society for Infectious and Tropical Diseases and the Swiss Respiratory Society. https://www.awmf.org/uploads/tx_szleitlinien/020-020I_S3_ambulant_erworbene_Pneumonie_Behandlung_Praevention_2016-02-2.pdf. [Accessed 23 March 2022]
- 23 Chebib N, Cuvelier C, Malézieux-Picard A, Parent T, Roux X, Fassier T, *et al.* Pneumonia prevention in the elderly patients: the other sides. *Aging Clin Exp Res* 2021; **33**:1091–1100.
- 24 Pittet JF, Hu PJ, Honavar J, Brandon AP, Evans CA, Muthalaly R, *et al.* Estrogen alleviates sex-dependent differences in lung bacterial clearance and mortality secondary to bacterial pneumonia after traumatic brain injury. *J Neurotrauma* 2021; **38**:989–999.