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ORIGINAL RESEARCH article

Impact of measuring pneumonia severity index (PSI) in the management of community-acquired pneumonia in the Emergency Department

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Abstract: Community-acquired pneumonia is a prevalent disease in the Emergency Department (ED). The literature reveals that clinical practice could not be related with guideline recommendations. The aim of this study is to determine the impact of the implementation of the recommendations of the Spanish Society of Emergency Medicine in the Hospital Clínico Universitario Lozano Blesa (Zaragoza) ED in the management of community-acquired pneumonia. Use of Pneumonia Severity Index (PSI) estimation was used to assess the adherence. This study was carried out from December 2014 to February 2015. Data was compared with the previous two months. The indicators management (discharge or admission decision, adequacy and anti-biotherapy) as well as the incidence of PSI estimation before and after the intervention in these parameters were evaluated. 209 patients were included, 97 before the intervention and 112 after the intervention. No significant differences were observed in the calculation of PSI. A significant decrease in admissions was observed after the intervention in the patients in whom the PSI was calculated (68.8% vs. 45.0%, $p<0.05$). A greater use of the Observation Room was aimed at those patients in whom the PSI was calculated (06.3% vs. 17.5%, $p<0.05$). PSI calculation significantly increased antibiotic prescription adherence (88.9% vs. 75.2%, $p<0.05$). There were no modifications in the prescription after the intervention. In conclusion, PSI is a useful and effective measure to achieve greater adherence to the recommendations. However, despite the positive trend in the use of the PSI and its interpretation, a low-intensity intervention is not sufficient to generalize its use.

Introduction

Community-acquired pneumonia (CAP) is the leading cause of death from infectious disease in developed countries (10.0% to 14.0%, depending on age and associated risk factors) and is the origin of a large part of complications admitted to the Emergency Department (ED), including sepsis and septic shock [1, 2]. In addition, pneumonia is the third leading reason for hospital admission accounting for 54,4000 hospitalizations from the ED annually [3]. These rates are extremely important due to the great variability existing between different centers and among clinicians in the approach and management of all the diagnostic-therapeutic

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processes of patients with CAP [4-6]. This fact may be one of the reasons that explain the existence of different hospital admission rates, the choice of antibiotic regimen, the intensity of care or the use of resources [7]. This variability implies that the prognosis and evolution of patients with CAP also be different [8]. It is estimated that 75.0% of all CAP are attended in the ED, which reveals the important role of the emergency physician in the initial management of these processes [1, 3, 7]. The decisions to be made by the emergency physician are critical, including the requirement of hospital admission, the appropriate location and the care that the patients require. All of them determine the prognosis of the patient, the requirement of laboratory tests and microbiological studies, the election of antimicrobial agents, the intensity of clinical observation and the use of socio-sanitary resources [7]. All these measurements are related to the final costs, which increase from 08 to 25 times in the patients admitted to the hospital compared with the discharge from the ED [9]. Along with the decision of the patient's destination, the early administration of the antimicrobial agent and hemodynamic and respiratory support measures are the most important factors in the evolution and mortality of patients with CAP [10]. Due to that, in recent years several authors have developed protocols or clinical practice guidelines (CPG) to manage these patients in the ED, especially critical patients [11-14]. Most of them have been performed by specialists in respiratory medicine, analyzing only the patients admitted to the hospital, although others have recently been published that include patients from the ED [15, 16]. While the effectiveness and efficiency of CPG are recognized, it is observed a low rate of adherence, and up to 35.0%-65.0% confess not using them [17, 18]. Due to that, the correct implementation of CPG in the ED agreed with the rest of the specialists and adapted to the center is probably the main tool to decrease clinical variability and improve process management [15, 16]. Thia aimed to determine the adherence in the management of ED in the CAP healthcare process and the impact of a low intensity intervention attending the recommendations of the Spanish Society of Emergency Medicine [18] about the CAP healthcare process. Pneumonia Severity Index (PSI) estimation was used to assess the adherence. Discharge or admission decision, adequacy and anti-biotherapy will be the indicators of management compared before and after the intervention.

Materials and methods

The study was carried out in the Hospital Clínico Universitario Lozano Blesa (Zaragoza). It is a third-level center with 800 beds belonging to the Aragon Health Service (SALUD) with a reference area of 275,000 inhabitants. The ED has an internal medicine area attended by emergency physicians of its own staff and residents of different medical specialties.

Study design: Observational, single-blind study with prospective follow-up of patients in two phases: before and after an intervention consisting of the implementation of the recommendations of the Spanish Society of EM [19] together with training sessions on it to all emergency physicians and residents of the center.

Study period and studied population: The study was carried out from December 1st, 2014 to February 1st, 2015. Before this period (November 2014), the training and different sessions about the recommendations were realized in the ED. To compare the results of the intervention, data was compared with a retrospective cohort of the previous two months (September 25th, 2014 to November 25th, 2014). To be included, the patients had to meet the following criteria: be adults (≥18 years old) and diagnosed with CAP in the ED by their responsible doctors. Immunosuppressed patients and patients hospitalized in the previous two weeks were excluded. Subjects in which the responsible doctor did not maintain the final diagnosis of CAP after 30 days (codes 481, 482, 483, 485, 486 and 507 of the International Classification of Diseases, Ninth Revision, Clinical Modification [ICD-9-MC]) and to those who had a final diagnosis of a different etiology were also excluded. Nor were patients who were diagnosed with a second episode of CAP during the study period included in the study. The study met the ethical standards of the hospital and was approved by the Clinical Research Ethics

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Committee of Hospital Clinico Universitario Lozano Blesa (Zarazona) Hospital (2014). The follow-up of all the patients was carried out through the computerized clinical history of the ED, Hospital and Primary Care.

Study intervention: Between November 25th and 30th, 2014, the recommendations of the Spanish Society of Emergency Medicine [19] were delivered completely and in a diptych, and training sessions on it were given to all emergency physicians and residents of the center, asking them to systematically apply the recommendations from now on. To evaluate and analyze the performance of the emergency physician in each case, it was defined as "adequate management" when there was agreement with the measures and treatments carried out by them with the aforementioned guide [19] and "inadequate management" when it did not coincide. This assessment was carried out independently for the request of complementary studies in the ED (laboratory, microbiological and biomarkers), prognostic assessment and decision of the patient's destination according to the PSI and for the choice and administration of treatment in the ED. To assess the prognosis and severity of patients with CAP and the admission decision, the PSI was used, whose risk classes were used according to the original authors' proposals [20], although different additional criteria were included according to the recommendations of the Spanish Society of Emergency Medicine, the main representation of EM in our area. These additional criteria were also explained and transmitted in the training sessions. Thus, it was considered that all the patients belonging to risk classes IV-V (PSI) and those belonging to risk classes' I-III should be admitted to the ward in the presence of one or more of the risk factors or additional criteria resumed in **Table 1**.

Table 1: Additional criteria and risk factors that determine the admission of patients

PaO_2 <60 mmHg or O_2 saturation by pulse oximetry <90.0%.
Evidence of uncompensated comorbidity.
Pleural effusion (encapsulated, ≥2 cm on chest radiograph in the lateral decubitus position).
Multilobar or bilateral radiological involvement.
Criteria for severe sepsis or septic shock.
High probability or suspicion of bacteremia due to the clinical situation and/or biomarkers such as PCR >90 mg/ml and/or procalcitonin >1.0 ng/ml.
Situations or factors that prevent correct home treatment such as oral intolerance, and social problems. (Dependent patient without an available caregiver, psychiatric disorders, alcoholism, etc.).
Lack of response to previous antibiotic treatment (after 72 h of starting adequate antibiotic treatment in the presence of clinical or radiological deterioration).

Variables collected: The patients were divided into the pre-intervention group (Pre-I) and the post-intervention group (Post-I). All the clinical, exploratory, radiological, analytical, patient destination (discharge, hospital admission, Observation Room (OBS) in the ED admission and sociodemographic variables included in the PSI [20] were collected. 20 variables establish the index, providing a score according to their summation. As a result, patients may be classified into five categories or classes (I-V) based on 30-day mortality. Thus, classes I - III group patients with mild CAP and low risk of mortality (<03.0%), class IV includes patients with an intermediate risk of dying (08.0%-10.0%), while class V is made up of patients with a high risk of dying (27.0%-31.0%). According to this classification, discharge from the ED and ambulatory treatment is recommended in classes I and II, unless there is hypoxemia. It is recommended admission to short-stay observation units in class III and hospital admission in classes IV and V. The value and grade of PSI was calculated in patients in whom it had not been collected.

Statistical analysis: Mean and standard deviation (SD), range, median and percentage, as appropriate, were used to describe the demographic, clinical, evolutionary and treatment characteristics of the patients in both phases. The comparison of percentage between phases (pre and post-implantation of the CPG) was performed

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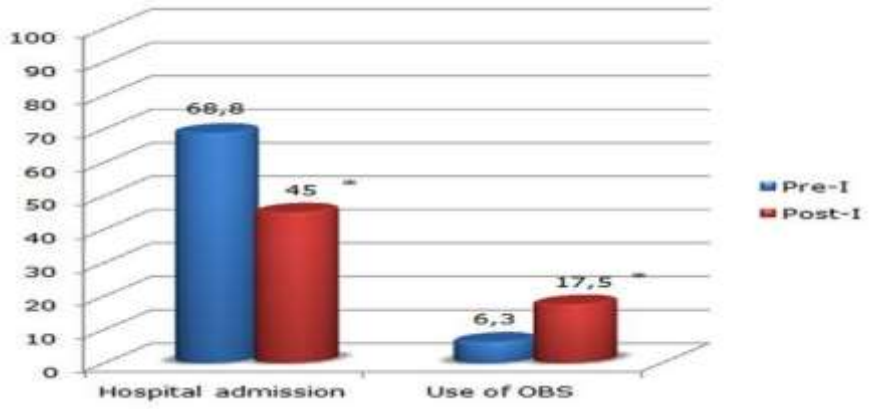
using the Chi-square or Fisher's exact test, as appropriate, and that of scale and ordinal variables, using the Student's *t*-test and Mann-Whitney *U*-test as applicable. The statistical analysis was performed with the SPSS-15 program for Windows and a value of $p<0.05$ was considered significant; all the contrasts were bilateral.

Results

In this study, 209 patients were diagnosed with CAP, 97 in the pre-intervention group (pre-I) and 112 in the post-intervention group (post-I). The mean age was 69.5±19.8 years and the distribution by sex showed 56.6% of men (n=118) and 43.5% of women (n=91). PSI was calculated in the pre-I group in 32.0% of the patients (n=31) whereas in the post-I in 35.7% (n=40), thus being calculated globally in 34.0% (n=71). There were no statistically significant differences between the two groups ($p>0.05$). Likewise, it is appreciated that in the retrospective calculation, more than half of the patients (n=57, 58.8%) in the pre-I group belonged to assessment groups IV and V, which are indicative of hospital admission. These values are similar to the post-I group (n=54 patients, 48.2%). Adherence to the recommendations attending PSI calculation and patients' destination was assessed before and after the intervention. Comparing the number of admissions, a decrease was observed in the patients in whom the PSI was calculated, this decrease being greater after the intervention (68.8% pre-I vs. 45.0% post-I, $p<0.05$) (**Figure 1**). Regarding the use of the OBS, a greater use of the OBS after the intervention was aimed at those patients in whom the PSI was calculated (06.3% pre-I vs. 17.5% post-I, $p<0.05$) (**Figure 1**). The total breakdown of the patients at the different PSI levels as well as their destination (home/admission and OBS) may be observed in **Table 2**.

Attending to antibiotic treatment, the most prescribed antibiotic was levofloxacin (n=120, 57.4% of the total), followed by amoxicillin-clavulanic (n=36, 17.2%), levofloxacin + ceftriaxone (n=09, 04.3%), moxifloxacin (n=09, 04.3%), ceftriaxone plus azithromycin (n=08, 03.8%), imipenem (n=05, 02.4%), amoxicillin-clavulanic plus azithromycin (n=05, 2.4%), cefditoren (n=01, 00.5%), and others (n=16, 07.7%). The most frequent lack of adherence was the non-association of macrolide with beta-lactam in admitted patients (12.9%). As previously observed in patients' destinations where PSI was calculated, in those patients in whom the PSI was determined, greater adherence to the recommendations was observed (88.9% vs. 75.2%, $p<0.05$) (**Figure 2**). There were no changes in the prescription after the intervention was performed (80.4% of adequacy in pre-I and 79.5% in post-I, $p>0.05$). All this data may be observed in **Table 2**. A decrease of hospital admissions was observed in the patients in whom the PSI was calculated after the intervention. In addition, a greater use of the OBS after was aimed at those patients in whom the PSI was calculated.

Figure 1: Patient's PSI score attending the area of admission prior and after intervention



PSI: Pneumonia Severity Index, OBS: Observation Unit, Pre-I: Pre-intervention group, Post-I: Post-intervention group, *p<0.05

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Table 2: Patients distribution and destination attending to their PSI index						
Patients' destination after ED (Home/Admission) attending to PSI evaluation or not in the ED						
PSI no calculated						
PSI value	I n=19	II n=16	III n=22	IV n=61	V n=20	Total n=138
Home n (%)	16 84.2	06 37.5	04 18.2	04 6.6	00 0.0	29 21
Admission n (%)	03 (15.8%)	18 (81.8%)	18 (81.8%)	57 (93.4%)	20 (100%)	109 (71%)
PSI calculated						
PSI value	I n=16	II n=10	III n=15	IV n=26	V n=04	Total n=71
Home n (%)	15 (93.7%)	09 (90.0%)	08 (53.3%)	00 (00.0%)	00 (00.0%)	32 (45.1%)
Admission n (%)	01 (06.3%)	01 (10.0%)	07 (46.7%)	26 (100%)	04 (100%)	39 (54.9%)
Patients distribution attending to PSI						
Pre-I	I n=12 (12.4%)	II n=12 (12.4%)	III n=16 (16.5%)	IV n=45 (46.3%)	V n=12 (12.4%)	Total n=97
Post-I	I n=23 (20.5%)	II n=14 (12.5%)	III n=21 (18.8%)	IV n=42 (37.5%)	V n=12 (10.7%)	Total n=112
Total	I n=35 (16.8%)	II n=26 (12.4%)	III n=37 (17.7%)	IV n=87 (41.6%)	V n=24 (11.5%)	Total n=209
Patients' destination (Home/Admission) after the attendance in the ED						
Pre-I group						
PSI value	I n=12	II n=12	III n=16	IV n=45	V n=12	Total n=97
Home n (%)	n=11 (91.7%)	n=05 (41.7%)	n = 05 (31.3%)	n=04 (08.9%)	n=00 (00%)	n=24 (24.7%)
Admission n (%)	01 (08.3%)	07 (58.3%)	11 (68.7%)	41 (91.1%)	12 (100%)	73 (75.3%)
Post-I group						
PSI value	I n=23	II n=14	III n=21	IV n=42	V n=12	Total n=112
Home n (%)	20 (87.0%)	10 (71.4%)	07 (33.3%)	00 (00.0%)	0 (00.0%)	37 (33.0%)
Admission n (%)	03 (13.0%)	04 (28.6%)	14 (66.7%)	42 (100%)	12 (100%)	75 (67.0%)
Total						
PSI value	I (n=35)	II (n=26)	III (n=37)	IV (n=87)	V (n=24)	Total (n=209)
Home n (%)	31 (88.6%)	15 (57.7%)	12 (32.4%)	04 (04.6%)	00 (00.0%)	61 (29.2%)
Admission n (%)	04 (11.4%)	11 (42.3%)	25 (67.6%)	83 (95.4%)	12 (100%)	148 (70.8%)
Use of Observation Room (OBS)						
PSI no calculated		Pre-I (n=92, 94.8%)		Post-I (n=103, 92%)		Total (n=195, 93.3%)
PSI calculated		Pre-I (n=05, 5.2%)		Post-I (n=09, 8%)		Total (n = 14, 6.7%)
Adequacy of antibiotic treatment attending to PSI evaluation or not						
PSI no calculated		No adequate (n=34, 28.8%)		Adequate (n =103, 75.2%)		Total (n=137, 100%)
PSI calculated		No adequate (n=08, 11.1%)		Adequate (n=64, 88.9%) *		Total (n=72, 100%)
Total		No adequate (n=42, 20.1%)		Adequate (n=167, 79.9%)		Total (n=209, 100%)
Adequacy of antibiotic treatment						
Pre-I		No adequate (n=19, 19.6%)		Adequate (n=78, 80.4%)		Total (n=97, 100%)
Post-I		No adequate (n=23, 20.5%)		Adequate (n=89, 79.5%)		Total (n=112, 100%)
Total		No adequate (n=42, 20.1%)		Adequate (n=167, 79.9%)		Total (n=209, 100%)

PaO2: Partial pressure of oxygen in arterial blood; O2: Oxygen; PCR: C-reactive protein.

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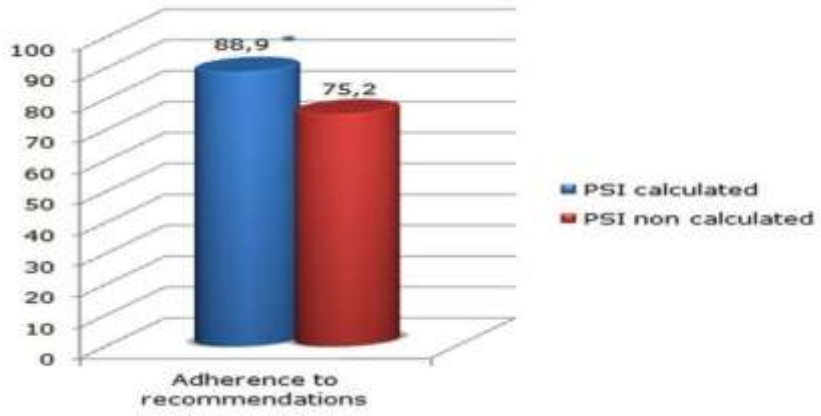
Figure 2: Antibiotic adherence attending the measurement or not of PSI score



In those patients in whom the PSI was calculated, greater adherence to the antibiotic recommendations' prescription was observed. PSI: Pneumonia Severity Index, *p<0.05.

Discussion

The implementation of a CPG in an ED that includes biomarkers of inflammation and infection as well as comorbidities and physical exploratory signs may become an effective tool to decrease the variability management of CAP. It includes the request for analytical and microbiological studies, the administration of the appropriate early treatment and the final destination of the patient. In addition, it improves the overall mortality of the process, decreases the incidence of improper discharges and inadequate admissions (and its consequences) and reduces the time necessary to achieve clinical stabilization and, consequently, decreases hospital stay. PSI estimation increases the adherence to CPG, especially attending to the patient's destination as well as antibiotic treatment, as we observed. The intervention did not evaluate mortality rates as well as hospital stay, being one limitation of the study in the measure of the impact of PSI evaluation. However, after our brief intervention, we observed that the PSI calculation decreased a number of hospital admissions, increased admission in OBS and the adherence to recommendations of GPC was higher. It has previously been observed that utilization of CAP management guidelines may improve clinical outcomes [11, 21, 22]. However, while the benefits of adherence to CAP management guidelines are clear and accepted universally as a goal in CAP management, strategies aimed at guideline implementation have met with mixed success [23, 24]. Our adherence ratio to the recommendations of CAP management (32.0% in pre-I group, 35.7% in post-I group, 35.0% globally) is similar to the previously published data [1, 25].

The decision of hospital admission of the patient or not will determine the request for complementary studies and the type of treatment and, consequently, the prognosis and evolution of the patient. Due to that, it is important to reduce improper registrations and unjustified admissions. It is observed in the literature that the routine implantation of a CPG in an ED that incorporates the PSI causes a decrease in the percentage of unjustified admissions, in addition to greater adequacy of the place of treatment as well as the adequacy and precocity of antibiotic treatment [15, 26] as we observed. Our results revealed a significant decrease in admissions in the patients in whom the PSI was calculated, this decrease being greater after the intervention (68.8% pre-I vs. 45.0% post-I, p<0.05). In addition, it is known that the variability of the percentage of admissions between different centers and doctors is very large when a CPG is not followed, and even when adherence is high, given the existence of criteria or reasons not contemplated in the PSI [4, 5]. Some examples are observed in the literature. In an observational study carried out in 12 ED with high follow-up of a CPG

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with the PSI scale, the authors observed that 37.4% of the patients with PSI I-III were admitted and 03.2% of the cases with PSI IV-V were discharged [18]. These authors were in line with the previous studies where 44.7% of low-risk patients (PSI I-III) were admitted, and of these, 20.0% had no justification or any criteria for doing so. In another recent study [27], to assess the adequacy of hospital admissions for CAP, a lower proportion of inadequate admissions (06.07%) was found in the low-risk group (PSI I-III) but a large proportion of undesirable discharge (according to the PSI and additional criteria), which reached 32.89%. As we commented previously, we observed a decrease in the global admission rate from 68.8% to 45.0% after the intervention in the patients for whom the PSI was calculated. This result was statistically significant, observing a trend of adequacy to recommendations if PSI was calculated, especially in PSI scores of I-III. However, this data was not correlated with the intervention in a general manner, being not observed any statistical differences excepting the increased use of OBS. Our results agree with the previous studies, where the estimation of PSI observed a non-adherence to the GPC [27]. However, our inadequacy was mostly due to inappropriate admissions other than inappropriate admissions of discharges with PSI I-III. These results could be explained due to the existence of clinical, social and capacity aspects for oral treatment that are not recognized in the PSI and sometimes justify admission [28, 29]. Antibiotic adherence also increased in a significant manner in our study if PSI was calculated. However, we do not observe any differences after the intervention. As previous results observed in our research, it may be due to the low strength of the intervention. However, these results agree with the previous data, observed an increased adherence to recommendations and validation of PSI to antibiotic prescription, especially if a multi-faceted education intervention is performed [30].

Conclusion: The PSI calculation is confirmed as a useful and effective measure to achieve greater adherence to the CPG. Likewise, the PSI calculation improves adherence to empirical treatment recommendations in CAP. However, despite having observed a positive trend in the use of the PSI and its interpretation, a low-intensity intervention such as the one developed in our work is not sufficient to generalize its use, so other strategies should be considered.

Author contributions: EEZ, MRG & FJRR conceived and designed of the study. EEZ & MRG collected data. AGN, BSB, JGB & FJRR contributed to the analysis of data. EEZ, MRG & FJRR contributed to the analysis and interpretation of data. All the authors have drafted, revised and approved the final version of the manuscript and agreed to be accountable for its contents.
Conflict of interest: The authors declare the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.
Ethical issues: Including plagiarism, informed consent, data fabrication or falsification and double publication or submission were completely observed by the authors.
Data availability statement: The raw data that support the findings of this article are available from the corresponding author upon reasonable request.
Author declarations: The authors confirm that all relevant ethical guidelines have been followed and any necessary IRB and/or ethics committee approvals have been obtained.

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