European Journal of Internal Medicine 31 (2016) 50–54

Contents lists available at ScienceDirect

European Journal of Internal Medicine

journal homepage: www.elsevier.com/locate/ejim

Original Article

Circadian variation of cardiogenic pulmonary oedema

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ARTICLE INFO

Article history:
Received 4 September 2015
Received in revised form 6 February 2016
Accepted 14 February 2016
Available online 28 February 2016

Keywords:
Cardiogenic pulmonary oedema
Circadian variation
Prehospital

ABSTRACT

Introduction: Circadian variation of in-hospital acute cardiogenic pulmonary oedema (CPE) with the highest occurrence in the early morning has been reported repeatedly. However, no study evaluating circadian variation of CPE in the field has been published. Therefore, we decided to evaluate the circadian variation of CPE in the Central Bohemian Region of the Czech Republic in the patients treated by regional emergency medical service (EMS) and analyse its association with baseline blood pressure in the field.
Methods: We extracted all dispatches to CPE cases from EMS database for the period from 1.11.2008 to 30.6.2014 and analysed for circadian variation. We identified the patients presenting with CPE coupled with arterial hypertension (systolic blood pressure >140 mm Hg) and hypotension (systolic blood pressure <90 mm Hg) and compared the subgroups (both subgroups include 2744 subjects).
Results: In 4747 episodes of CPE, maximal occurrence was detected in the ninth hour in the morning, representing 7.7% of all CPE episodes ($p < 0.05$). While CPE with hypertension (2463 subjects) reached maximal occurrence also in the ninth hour (7.4% of all cases, $p < 0.05$), CPE with hypotension (281 patients) was most frequent in the fourteenth hour (8.6% of all cases, $p < 0.05$).
Conclusion: The highest occurrence of CPE was observed in the ninth hour in the morning in our study. Moreover, differences in circadian variation between CPE with hypertension and hypotension were identified. Knowledge of these patterns may have an impact on the logistic of prehospital emergency care and on preventive measures in the patients who have previously undergone CPE.

1. Introduction

Cardiogenic pulmonary oedema (CPE) is a common indication for dispatch of emergency medical services. Pattern of circadian variation of CPE episodes has been published by several epidemiological studies [1–3]. Most of them described the peak incidence in the morning, other identified it during night hours [2–9]. However, the studies analysed especially the population of CPE patients in hospitals or emergency departments, which can be burdened by error of selection. There has not been presented any study that would address circadian variation of CPE and its clinical subgroups in prehospital emergency care. Recognition of regular variations of occurrence of cardiovascular emergencies in time may be of major importance for optimising the operation of emergency medical services and also for implementation of chronotherapeutic approach to the management of the diseases. Therefore, we decided to evaluate the circadian variation of CPE in the Central Bohemian Region of the Czech Republic in the patients treated by regional emergency medical service and analyse its association with baseline blood pressure in the field.

2. Materials and methods

Emergency medical service of the Central Bohemian Region is the exclusive provider of primary prehospital emergency care in the Central Bohemian Region, Czech Republic. The region includes both the rural and urban population, in total of 1 315 299 inhabitants on a total area of 11 015 km^2. A computer search of patients with dyspnoea between 1.10.2008 and 30.6.2014 was conducted. Only those with CPE were entered in the study. Each patient was managed by a physician in the field. Criteria for considering the patient having CPE were leading complaint

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http://dx.doi.org/10.1016/j.ejim.2016.02.017
0953-6205/

of shortness of breath, presence of bilateral pulmonary rales on the prehospital physical examination, and the absence of another explanation of the clinical setting. The criteria were evaluated by two investigators independently. The results of their analysis were compared with the diagnosis established by the physician in the field. In case of full accordance to the diagnosis of CPE, the patients were selected for the analysis. In the case that both investigators and the physician in the field excluded pulmonary oedema, the patient was not included. If there was a partial mismatch, the case was carefully re-evaluated including personal consultation with the EMS physician and in-hospital documentation.

We analysed the occurrence of episodes of CPE in 24 hours during the defined period. The 1st hour has been the period from 00:00:01 to 01:00:00, the 24t^h hour has been the period from 23:00:01 to 24:00:00. The time of the occurrence was defined as time of received call to dispatch centre. While for circaseptan variation analysis, the same collection period as for circadian was used, for circannual variation, only patients from 01.01.2009 to 31.12.2013 were included.

According to the first measured systolic blood pressure (SBP) in the field, we assigned the patients into two groups for further analysis: CPE with hypertension (SBP > 140 mm Hg, CPE_{hyper}) and CPE with hypotension (SBP < 90 mm Hg, CPE_{hypo}) and compared occurrence of CPE events in the groups within 24 hours. While CPE cases with normotension (SBP ≥ 90 and ≤ 140 mm Hg) represent a grey zone for emergent distinguishing the causes of CPE in the field, this subgroup was not undertaken to further analysis. Initial blood pressure measurement was taken once, using oscillometric automatic sphygmomanometer validated according to standardised protocol and checked periodically through calibration. Repeated initial measurement was performed only by individual clinical needs in some cases.

2.1. Statistical analysis

For analytic purposes, mean values ± SD or percentages were calculated as necessary. Differences between groups were compared using the χ^2 test, and statistical significance was calculated by the Fischer exact test for alternative variables. Statistical significance for continuous variables was determined by the paired Student t-test. Comparison of subgroups according to systolic blood pressure was performed by ANOVA analysis. Data were analysed using Microsoft Excel 2007 (Microsoft, Redmond, WA, USA) and JMP 3.2 statistical software (SAS Institute, Cary, NC, USA). A p value of <0.05 was considered statistically significant.

Table 1
Baseline characteristics of CPE patients.

VARIABLE	All CPE episodes	CPE_{hyper} episodes	CPE_{hypo} episodes	p
Number of the cases (n)	4747	2463	281	
Age (years, mean ± SD)	75.0 ± 10.5	75.2 ± 10.3	73.4 ± 11.1	0.006
Men/women (%)	49/51	49/51	47/53	>0.050
Diabetes mellitus (n/%)	1424/30.0	726/29.5	83/29.5	>0.050
COPD/asthma bronchiale (n/%)	513/10.8	263/10.7	31/11.0	>0.050
Number of STEMI patients (n/%)	222/4.7	74/3.0	51/18.1	<0.001
Initial heart rhythm				
Sinus rhythm (n/%)	2668/56.2	1379/56.0	158/56.2	>0.050
Atrial fibrillation (n/%)	1239/26.1	643/26.1	74/26.3	>0.050
Other rhythm/not known (n/%)	840/17.7	441/17.9	49/17.5	>0.050
Systolic arterial blood pressure (mm Hg, mean ± SD)	148 ± 39	178 ± 25	81 ± 9	<0.001
Diastolic arterial blood pressure (mm Hg, mean ± SD)	84 ± 22	97 ± 16	46 ± 19	<0.001
Mean arterial blood pressure (mm Hg, mean ± SD)	105 ± 26	124 ± 17	57 ± 12	<0.001
Heart rate (beats/min., mean ± SD)	99 ± 27	101 ± 24	97 ± 31	0.010
SpO_2 (%, mean ± SD)	85 ± 13	85 ± 11	80 ± 17	<0.001
Breath rate (breaths/min., mean ± SD)	24 ± 6	24 ± 6	23 ± 7	0.009

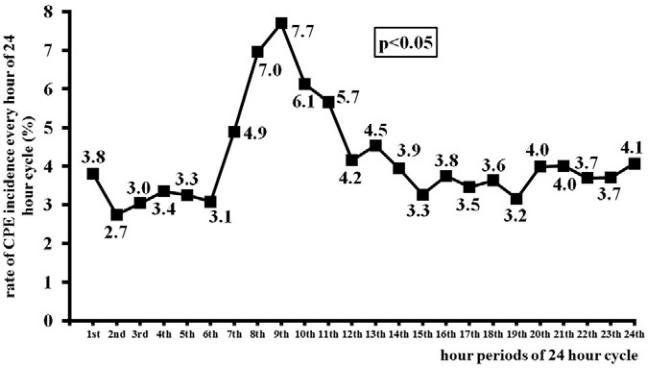

Fig. 1. Circadian variation of CPE episodes in all patients. CPE, cardiogenic pulmonary oedema.

3. Results

For the period from 1.10.2008 to 30.6.2014, a total of 15 000 EMS dispatches for dyspnoea was identified, 4747 were classified as CPE. This group was the subject of further analysis. Table 1 provides baseline clinical characteristics of the patients. As much as 51.9% CPE episodes were classified as CPE_{hyper}, 5.9% as CPE_{hypo}, and 40.3 % were accompanied by normotension. In 89 patients, values of blood pressure were not available.

Fig. 1 shows circadian variation of all episodes of CPE during defined period. There is increase of occurrence in the period from the 8th to the 11th hour with a peak in the 9th hour ($p < 0.05$). Analysis of circadian variation in each year separately reflected the same pattern with the maximal incidence in the 9th hour.

Fig. 2 demonstrates circadian variation of CPE episodes in the CPE_{hyper} and CPE_{hypo} groups. While the former followed the pattern with the peak occurrence in the 9th hour, CPE_{hypo} group exhibited an increase in incidence during the period from the 8th to 14th hour with the peak in the 14th hour.

Breath rate, heart rate, presence of atrial fibrillation, diabetes mellitus, chronic pulmonary obstructive disease, and peripheral oxygen saturation had no significant impact on circadian variation of CPE. In the subgroup of the patients presenting with CPE_{hypo} due to ST segment elevation myocardial infarction (STEMI), the peak incidence was observed in the 11th hour (23.5 %, $p = 0.010$).

Circaseptan variation of CPE episodes shows Fig. 3. In unselected group of CPE patients and in the CPE_{hyper} group the peak incidence was on Monday, while minimal occurrence on Thursday ($p < 0.05$).

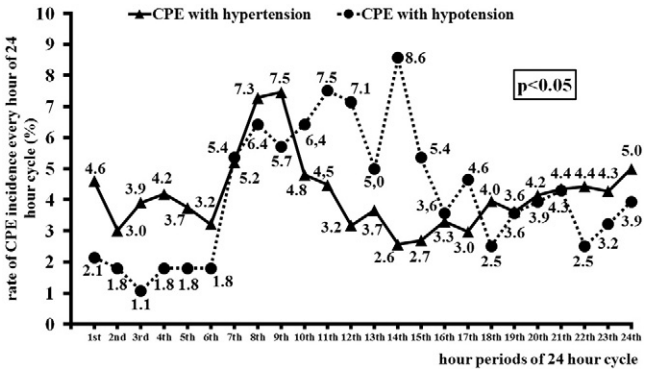

Fig. 2. Circadian variation of CPE episodes in patients presenting with hypertension and hypotension. CPE, cardiogenic pulmonary oedema