Out-of-hospital helmet CPAP in acute respiratory failure reduces mortality: a study led by nurses

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ABSTRACT: *Out-of-hospital helmet CPAP in acute respiratory failure reduces mortality: a study led by nurses. G. Garuti, G. Bandiera, M.S. Cattaruzza, L. Gelati, J.F. Osborn, S. Toscani, M. Confalonieri, M. Lusuardi.*

Background and Aim. Acute respiratory failure (ARF) is a condition that must be treated as quickly as possible. Continuous Positive Airway Pressure (CPAP) is a common method used to treat ARF in hospital.

The main objective of our study was to investigate the effect of CPAP prior to admission to the emergency room, on the reduction of endotracheal intubation, in-hospital mortality and on the length of stay in hospital (HLOS).

Methods. A prospective, observational (non-randomised) study with a historical control group. Data from 3 groups of patients with ARF, irrespective of cause, was collected: pre-hospital CPAP (PHCPAP) group, i.e. 35 patients treated with a helmet CPAP in the ambulance, by trained nurses (mean age, years 80.1±7.9 SD; 14 males); hospital CPAP (HCPAP) group, i.e. 46 patients treated with helmet CPAP in the hospital emergency room (mean age 78.6±6.9 SD; 27 males), and a historical control group of 125 patients treated with medical therapy only (mean age 76.7±5.5 SD; 52 males). CPAP was delivered via a helmet interface.

Results. Compared with standard medical therapy, helmet CPAP (pre and in-hospital) reduced mortality by 77 % (*p*=0.005), while pre-hospital helmet CPAP reduced it by 94% (*p*=0.011), after adjustment for age, sex, severity of clinical conditions at entry and diagnosis upon admission.

HLOS was reduced, compared with standard medical therapy, by 63.5% and by 66% (adjusting for age, sex, severity of clinical conditions at entry and diagnosis at admission) with helmet CPAP (pre and in-hospital) and with helmet CPAP in the ambulance, respectively (*p*<0.0001).

Conclusions. Treating patients with ARF of any cause, with CPAP by trained nurses, before hospital admission, is safe, reduces mortality and the length of stay needed in hospital.

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Introduction

Treatment of acute respiratory failure with non-invasive ventilation support, Continuous Positive Airway Pressure (CPAP) in particular, is increasing in Emergency Medical Services, because it reduces or delays the need for endotracheal intubation [1] but also because of its feasibility by trained nurses early in out-of-hospital settings [2].

CPAP is very practical since it requires limited equipment, which is both small and light and many devices can use pressurised oxygen as the only power source [3].

In most studies in the emergency setting, CPAP was applied to patients with acute cardiogenic pulmonary edema (ACPE) [4]. In ACPE the efficacy of CPAP on ventilation and oxygenation depends on several interdependent mechanisms, such as, an increase in alveolar pressure, a reduction in lung collapsibility, an increase of partial pressure of oxygen, a better O_2 diffusion through the alveolar barrier, a squeezing effect on the interstitial lung fluid that is forced toward the vascular and lymphatic beds. Cardiac performance is also improved through a reduction of preload, derived from an increase of intrathoracic pressure, without reducing cardiac output [5].

Kallio *et al.* retrospectively evaluated CPAP in a mobile intensive care unit on patients with presumed acute severe pulmonary oedema, and found improved oxygenation and lowered respiratory rate, heart rate, and systolic blood pressure [3].

The application of CPAP in COPD and asthma exacerbation is still a matter for debate. A poten-

tial mechanism for the efficacy of CPAP is that its positive pressure counterbalances the increased intrinsic PEEP (positive end-expiratory pressure) due to the air trapped in peripheral airways. Thus the expiratory time increases allowing for the small airways to empty more easily [6].

CPAP is increasingly applied in critical settings, including out-of-hospital emergency [7] and its relative ease of use means that after adequate training, non medical personnel such as nurses are able to use it.

Articles already published demonstrate the efficacy of the technique, focusing in particular on vital parameters and risk of intubation [1-7]. A recent paper has evaluated its use by non medical personnel, reporting a 30% reduction in tracheal intubation and 21% reduction in mortality compared with usual care in selected out-of-hospital patients [2].

Materials and Methods

Study design

This is a prospective, observational (non-randomized) study on patients who received CPAP in the ambulance (pre-hospital) or in hospital. A historical control group of patients who received standard medical treatment was also included for comparison.

The aim of this study was to assess whether the early use of CPAP in ambulance, with a standard protocol applied by trained non-medical personnel, can be safe and effective in patients with acute respiratory failure of undefined cause. In particular, we evaluate whether the early use of CPAP in the ambulance by trained nurses can reduce endotracheal intubation, in-hospital mortality and length of stay. Furthermore, the outcomes have been compared to a historical control group who were not treated with CPAP but only with usual medical treatment not defined by a standard protocol. The use of concurrent controls was considered unethical given the evidence for the benefit of CPAP.

This study was carried out at the Emergency Department of the General Hospital of Mirandola (Modena, Italy) which is the referral point of the area and performs about 30,000 interventions per year.

The design of the study was approved by the Institutional Review Board of the hospital.

Patients

All patients with a diagnosis of acute respiratory failure (independently of cause) in the period 1st January - 30th June, 2006 were eligible for prospective evaluation. They were compared with an historical control group admitted in the period 1st July - 31st December, 2005, before the introduction of CPAP therapy.

Three groups of patients were considered:

1. Pre-hospital CPAP (PHCPAP): patients treated with helmet CPAP in an ambulance by trained nurses.

2. Hospital CPAP (HCPAP): patients treated with helmet CPAP on admission to the Emergency Unit under medical supervision; these subjects arrived at the emergency department spontaneously or with a mobile emergency unit not equipped for CPAP treatment.

3. Historical control group: patients treated with standard medical therapy (drugs and oxygen) at admission to the Emergency Unit under medical supervision.

Patients were enrolled in the study if they fulfilled the following inclusion criteria: paroxysmal dyspnea, respiratory rate ≥ 25 breaths/minute, $SaO_2 \leq 90\%$ while breathing with O_2 bag mask, use of accessory inspiratory muscles, paradoxical breathing.

The clinical and drug history of the patient was registered at home by the nurse.

Patients were excluded from the study if they had at least one of the following: politrauma or facial trauma, history of severe COPD, (i.e. subjects on long-term oxygen or mechanical ventilation or with previous episodes of hospitalisation for acute respiratory failure from an exacerbation), suspected or history of pneumothorax, need for immediate intubation, Glasgow Coma Scale (GCS) ≤ 9, shock or systolic arterial blood pressure ≤ 90 mmHg, inability to protect airways or vomiting, inability to cooperate for psychomotor agitation.

A formal diagnosis was carried out following admission to hospital supported by case history, medical examination and a series of instrumental evaluations. In particular, diagnosis of pneumonia was based on a history of respiratory tract infection and the radiological finding of new pulmonary infiltrate at the chest x-ray. A label of COPD exacerbation required a previous diagnosis of COPD based on spirometric evidence of airways obstruction and exposure to tobacco smoking; a sustained worsening of symptoms (shortness of breath, quantity and color of phlegm) defined an exacerbation. The diagnosis of acute cardiogenic pulmonary edema was made based on symptoms and clinical signs, physical examination, ECG, chest X-ray, echocardiography and laboratory tests including blood gas analysis and specific biomarkers such as pro-brain natriuretic peptide.

Training of personnel

Nurses involved in the study for CPAP application received at least 2 month training by expert physicians and nurses. This training consisted of 2-hour-sessions, three times per week, including theoretical presentations on respiratory failure and practical training with CPAP devices.

Protocol

A) *CPAP application in ambulance*

At the site of first intervention, paramedical personnel started the procedure according to AMLS (Advanced Medical Life Support) stan-

dards; arterial blood pressure, electrocardiography, and non-invasive oxygen saturation were monitored. The procedure was explained to patients in order to obtain a verbal consent. An arterial sample for blood gases was taken from the radial artery with the patient breathing air directly in the home or on the ambulance before departure.

CPAP was applied in the ambulance by two trained nurses, before departure. The whole procedure was supervised by telephone, at the emergency centre by a physician, in charge of verifying inclusion and exclusion criteria. The helmet (Castar-Starmed, Mirandola, Italy) was applied to the patient before the ambulance departure, and then connected with a plastic tube to a source which mixes oxygen and compressed air (Flow-meter 546 Starmed, Mirandola, Italy) at flows to be adjusted according to a pre-defined table correlating oxygen and air combined flows with a definite FiO_2 (figure 1).

Only one nurse assisted the patients during the transfer to hospital, the second being the designated driver of the ambulance. The nurse regulated the CPAP and the resistance valve to a target SaO_2 of at least 92%, progressing according to the following scheme: CPAP 5 cmH_2O and 30% FiO_2, CPAP 7 cmH_2O and 40% FiO_2, CPAP 10 cmH_2O and 50% FiO_2. For safety reasons and technical limitation (maximal oxygen flows obtainable on the ambulance), the upper limit of performance was put at 10 cmH_2O and 50% FiO_2. During the transport to the hospital, the nurse was always in contact with the doctor at the emergency centre, to report vital parameters (arterial blood pressure, EKG, SaO_2) and exchange information for medical therapy. An arterial sample for blood gases was taken at 30', 60' and 120' during CPAP treatment. In the geographic area where the study was carried out distances to hospital require in general less than 30 minutes, therefore the arterial blood samples at 60' and 120' were always taken in the Emergency Department.

B) *CPAP application in hospital*

The protocol for patient selection and CPAP application was the same as on the ambulance.

The only difference with respect to the previous group was the possibility of increasing the CPAP performance with the same device to 15 cmH_2O and 60% FiO_2. The monitoring of vital parameters and the timing of arterial blood gases was the same as in the ambulance.

C) *Historical control group*

Clinical records of consecutive patients admitted to the emergency department for acute respiratory failure in the 6 months before the CPAP introduction were retrospectively evaluated. At that time, only medical treatment including oxygentherapy, administered with different devices, was available as first line intervention, without any definite protocol.

End-Points

The main objective of this study was the assessment of the efficacy of Helmet CPAP in the out-hospital setting, defined as improvement of clinical variables, reduction of endotracheal intubation, in-hospital mortality and hospital length of stay. A second objective was to compare the efficacy of CPAP in two different settings: outside the hospital (that is, in the ambulance) and in-hospital, with respect to standard medical therapy. A third objective was to evaluate CPAP as feasible treatment for acute respiratory failure (ARF) from different causes (not only acute pulmonary edema).

Data recording and analysis

During the study period, data from all patients enrolled was recoded on an Excel worksheet.

In-hospital mortality was cross-checked from clinical records and Hospital Discharge Records.

Descriptive statistical analysis included proportions for qualitative data and means ± standard deviation (SD) and standard error (SE) for continuous variables; analysis of variance and the *chi*-squared test were used, as appropriate, to evaluate statistical differences among the three groups.

Multiple logistic regression was used to investigate the independent effect of each variable on the outcome (in-hospital mortality) allowing comparisons between groups that can differ significantly at the baseline.

Cox's proportional hazard model was used to evaluate hospital length of stay in relation to the three different treatment groups and to control for potential confounders. All tests and *p*-values are two tailed and statistical significance was set at the 5% level.

Results

81 patients were treated with CPAP, 35 in the ambulance (PHCPAP group: 14 males mean age 80.1±7.9 SD; range 54-94 years), and 46

	Compressed air flow, L/min	O$_2$ flow, L/min
FiO$_2$ 30 %	18	2
FiO$_2$ 40 %	16	4
FiO$_2$ 50 %	13	7

Fig. 1. - Algorithm for the determination of FiO_2 with the oxygen / compressed air blender at a final flow of 20 L/min.

on admission to the emergency room (HCPAP group: 27 males, mean age 78.6±6.9 SD; range 68-90 years). The historical control group included 125 patients, 53 males, mean age 76.7±5.5 sd; range 58-96 years) (table 1).

The diagnoses at admission are reported for the three groups in figure 2; differences among percentages are statistically significant (*Chi* squared =13.4 with 4 degree of freedom, df; *p*=0.001).

Acute cardiogenic pulmonary edema was the most frequent cause of ARF, but varied from 52% in the control group to 71% in the PHCPAP. Pneumonia and AECOPD were the second most common diagnoses for HCPAP and Control groups respectively.

Analysis of variance of the three groups in table 1 demonstrated that PHCPAP patients had a baseline heart rate significantly higher, but after 120 minutes the decrease was larger than HCPAP and control patients treated in hospital (*p*<0.0001).

Baseline values of systolic and diastolic blood pressures did not differ among the 3 groups, but after 120 minutes control patients not receiving CPAP showed significantly higher levels (*p*<0.0001 and 0.002).

The control of the respiratory rate was more rapid in the PHCPAP group, but at 120 minutes there were no significant differences among the three groups.

PHCPAP patients had a more rapid improvement of SaO_2 than HCPAP and control patients, particularly important from a clinical point of view at 30 minutes (*p*=0.0001).

Modifications of pH were clinically important for the groups treated with CPAP, which at 120 minutes showed a regression of acidosis to pH values in the normal range, while in the control group acidosis persisted, although with a tendency to improve (*p*<0.0001).

The three groups showed no significant differences in PaO_2 and $PaCO_2$ at baseline. The correction of PaO_2 at 120' was more evident for the PHCPAP group (*p*<0.0001). $PaCO_2$ levels in PHCPAP and HCPAP patients regressed to normal at 120 minutes, while in the control group hypercapnia was still evident, consistent with the acidotic pH.

In table 1 a discrepancy can be noticed between values of PaO_2 and oxygen saturation at baseline, since PaO_2 is almost the same in the three groups, while SO_2 differs by nearly 10 points

Table 1. - Analysis of variance of age and clinical parameters

	Controls		HCPAP		PHCPAP		P =
	N = 125		N = 46		N = 35		
	mean	SE	mean	SE	mean	SE	
Età	76.74	0.57	78.65	0.95	80.06	1.08	0.0153
HR baseline	125.39	1.61	123.46	2.66	133.80	3.05	0.025
HR 120'	85.66	1.04	95.37	1.72	88.77	1.97	0.0000
SBP baseline	149.84	2.27	159.67	3.75	150.57	4.29	0.077
SBP 120'	134.28	1.01	127.83	1.67	124.11	1.91	0.0000
DBP baseline	89.92	1.22	93.48	2.02	86.86	2.31	0.094
DBP 120'	82.12	0.73	78.15	1.21	77.80	1.38	0.002
RR baseline	42.50	0.56	39.72	0.93	39.97	1.06	0.013
RR 30'	36.10	0.54	34.44	0.89	32.23	1.01	0.003
RR 60'	28.28	0.60	29.80	0.79	26.69	0.90	0.035
RR 120'	23.39	0.99	23.04	0.75	21.89	0.86	0.456
SO2 baseline	85.97	0.78	75.39	1.29	77.63	1.48	0.0000
SO2 30'	89.71	0.47	88.91	0.78	93.74	0.90	0.0001
SO2 60'	93.12	0.34	93.24	0.56	95.97	0.65	0.0005
SO2 120'	95.30	0.20	96.91	0.33	97.29	0.38	0.0000
pH baseline	7.22	0.01	7.27	0.02	7.23	0.02	0.022
pH 30'	7.24	0.01	7.33	0.01	7.29	0.02	0.0000
pH 60'	7.28	0.01	7.35	0.01	7.33	0.01	0.0000
pH 120'	7.29	0.01	7.37	0.01	7.36	0.01	0.0000
PO2 baseline	49.76	0.62	47.54	1.02	48.97	1.16	0.176
PO2 120'	99.90	4.15	104.98	6.84	138.43	7.84	0.0001
PCO2 baseline	45.22	1.02	48.89	1.68	46.20	1.93	0.178
PCO2 120'	50.10	0.88	43.00	1.44	42.60	1.66	0.0000
SAPS II	46.13	0.49	46.37	0.81	52.20	0.93	0.0000

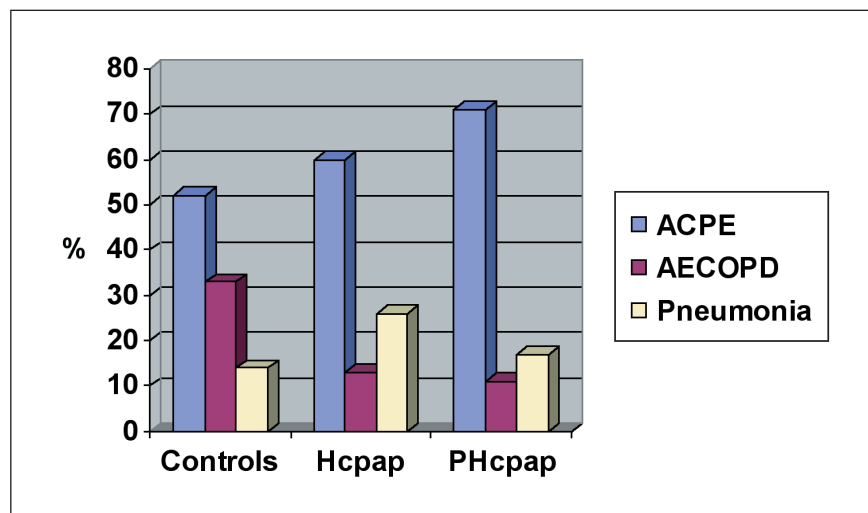HR = heart rate; SBP = systolic blood pressure; DBP = diastolic blood pressure; RR = respiratory rate.

Fig. 2. - Diagnosis at admission for the 3 study groups. (Differences among groups are statistically significant: *Chi* squared =13.4 with 4 df; p=0.001)

we found that, compared with control, the early application of helmet CPAP in the ambulance, reduced mortality by 94% (OR 0.06, 95% CI 0.01-0.53, *p*=0.011), after adjustment for sex, age, severity of clinical condition at entry (Heart Rate, Respiratory Rate, Glasgow Coma Scale, pH, pO_2, pCO_2) and diagnosis at admission, while the reduction in mortality attributed to the application of CPAP at admission to the emergency department was large, but not statistically significant (OR 0.40, 95% CI 0.13-1.23, *p*=0.1097) (table 2).

Diagnosis of pneumonia at admission has 3 times the risk of mortality, independent of sex, age, severity of clinical condition at entry (Heart Rate, Respiratory Rate, Glasgow Coma Scale, pH, pO_2, pCO_2) and use of CPAP (OR 3.25, 95% CI 1.17-9.04, *p*=0.024 (table 2).

(85.97 versus 75.39 and 77.63 %, respectively). Unfortunately, the retrospective collection of data did not allow us to evaluate in detail those factors either clinical or analytical causing such a discrepancy.

The SAPS II severity score was significantly higher in the PHCPAP group. Baseline SAPS II values did not differ between survivors (47.3±5.7 SD) and non survivors (47.0±7.1).

PHCPAP and HCPAP patients maintained a GCS of 15 from baseline to 30, 60, and 120 minutes. On the contrary, patients in the control group showed a modest, but significant deterioration in the same time interval (from 14.8±0.08 SE at baseline to 14.3±0.19 SE at 120 minutes).

No tolerance problems were reported for patients treated with CPAP.

Mortality rates during the hospitalisation period were 24% for the control group (30 out of 125 patients, despite application of noninvasive ventilation in the hypercapnic patients in the ward), 8.6% (7 out of 81) for patients treated with CPAP, with a remarkable difference between the PHCPAP (2.9%, 1 out of 35) and the HCPAP (13%, 6 out of 46) patients (*p*=0.0097).

Logistic regression analysis to evaluate mortality demonstrated that CPAP, independently of the site of application, reduced mortality by 77% (OR 0.23, 95% CI 0.08-0.64 *p*=0.005), as compared to usual drug therapy alone, after adjustment for age, sex, severity of clinical condition at entry (Heart Rate, Respiratory Rate, Glasgow Coma Scale, pH, pO_2, pCO_2) and diagnosis at admission.

When we considered the site of application of CPAP,

We could not evaluate the reduction in intubation rate associated with use of CPAP because in our study no patients needed intubation, either in the HCPAP group or in the PHCPAP group. Intubation occurred only among the patients belonging to the control group (11.2%), as assessed in the first intervention interval only, from home to the emergency department.

Hospital length of stay (HLOS) was significantly reduced using CPAP compared with pharmacologic treatment alone. The mean length of stay for the control group was 18.8 days (±8 SD) while for HCPAP patients it was 13.9 days (±9.6 SD) and for PHCPAP patients it was 12.0 days (±4.7 SD) (*p*<0.0001).

Table 2. - Logistic regression to evaluate mortality risk in patients treated with CPAP in hospital and in the ambulance (pre-hospital) CPAP versus control group (medical treatment)

Independent Variables	OR (95% CI)	P
AGE	1.04 (0.97 1.12)	0.2388
SEX	0.81 (0.34 1.90)	0.6244
Baseline Heart Rate	1.03 (1.00 1.05)	0.0450
Baseline Respiratory Rate	1.00 (0.94 1.08)	0.8927
Baseline Glasgow Coma Scale	0.76 (0.51 1.13)	0.1695
Baseline pH	8.72 (0.09 809)	0.3490
Baseline PaO_2	1.06 (0.99 1.13)	0.0993
Baseline $PaCO_2$	1.01 (0.96 1.06)	0.6962
AECOPD	1.36 (0.51 3.62)	0.5425
Pneumonia	**3.25 (1.17 9.04)**	**0.0241**
Hospital CPAP	0.40 (0.13 1.23)	0.1097
Pre-Hospital CPAP	**0.06 (0.01 0.53)**	**0.0112**

OR = odds ratios; CPAP = Continuous Positive Airways Pressure; AECOPD = Acute Exacerbation of Chronic Obstructive Pulmonary Disease.

Using Cox's proportional hazard model, controlling for sex, age, severity of clinical condition at entry (Heart Rate, Respiratory Rate, Glasgow Coma Scale, pH, pO_2, pCO_2) and diagnosis at admission, we found that patients who received CPAP reduced their stay in hospital by 63.5%, (p<0.0001). In particular, HLOS was reduced by 59% and by 66% respectively for HCPAP and PHCPAP groups (*p*<0.0001). Figure 3 shows the mean values of HLOS.

Discussion

In the latest 2 decades, treatment of ARF has been modified by the demonstration that non-invasive mechanical ventilation can be as effective as endotracheal intubation, but with reduced probability of adverse events [8, 9]. This study is the first comparing the same treatment in two different settings, ambulance and hospital.

This study on efficacy of CPAP confirms that important differences exist in outcomes when using CPAP in comparison with standard medical therapy; indeed in-hospital mortality and hospital length of stay were reduced, showing that CPAP is feasible and has considerable advantages.

In our study, the risk of death was reduced by 94% if CPAP was applied in the ambulance, while in patients starting CPAP on arrival in hospital, the mortality risk was reduced only by about 60%. This data collates with the most recent randomised controlled study of Thompson [2], that compares pre hospital CPAP with the standard therapy.

Mortality during the full hospitalisation period was 24% in the control group (despite application of non-invasive ventilation in the post-emergency period for the hypercapnic patients) while for all patients with CPAP, either on the ambulance or in emergency department, it was 8.6%. If CPAP alone were the cause of this difference, then 6-7 patients would need to be treated with CPAP to prevent one death. Both HCPAP and PHCPAP compared to controls showed statistically significant reductions of mortality, indeed, in hospital mortality in the HCPAP group was 13% (*p*=0.03) and in the PHCPAP group was 2.9% (*p*=0.005);

when HCPAP and PHCPAP mortality were compared, the reduction in mortality was not statistically significant, probably due to the small number of deaths observed. Again, if CPAP alone were the cause of these difference, 9 and 5 patients would need to be treated respectively with HCPAP and PHCPAP to prevent one death.

In addition to the potential benefit of CPAP on short-term survival, our data also show a statistically significant reduction of hospital length of stay. There is evidence that early application of CPAP reduces the time spent in hospital by more than 60%. The reduction is even higher (66%) for patients receiving CPAP in the ambulance. CPAP reduces hospital stay by 5 and 7 days respectively for HCPAP and PHCPAP, compared with control. Previous studies have shown a trend toward a decrease in HLOS, but were underpowered to detect a statistically significant effect [10].

Major criterions for the success of non-invasive ventilation, and of CPAP in particular, are early intervention [11] and the safe and easy application [12, 13]; CPAP has been used in different clinical settings [14] including emergency intervention in ambulance, but comparison of outcomes has been made only with controls not using CPAP [10].

This study is the first to compare the efficacy of the early application of CPAP in the ambulance with later application in hospital. It shows that the earlier CPAP is applied, the better the clinical results, the lower the in-hospital mortality and the length of stay. Mortality in the HCPAP group was 13% while in the PHCPAP group it was 2.9%; if again CPAP alone was the cause of this difference, then 10 patients would need to be treated with CPAP in the ambulance to prevent one death among the HCPAP.

Among the different interfaces that can be used (usually nasal or face masks) the helmet seems particularly suitable for application in the ambulance because it can be easily and rapidly put on, fixing is safe and steady, it requires minimal nursing adjustment, and it is well tolerated by patients (in our study indeed, no patients had problems with the helmet) [12, 13, 15]. The main strength of this study is the evaluation of ambulance CPAP.

Since our study was observational, it had no randomisation and hence, the three study groups statistically differ according to diagnosis at admission and severity of clinical condition at entry (age, heart rate, respiratory rate, SO_2, pH, SAPSII). Among the three groups, PHCPAP patients were those who had the most disadvantageous conditions at entry, but nevertheless showed the better prognosis. Conversely, it
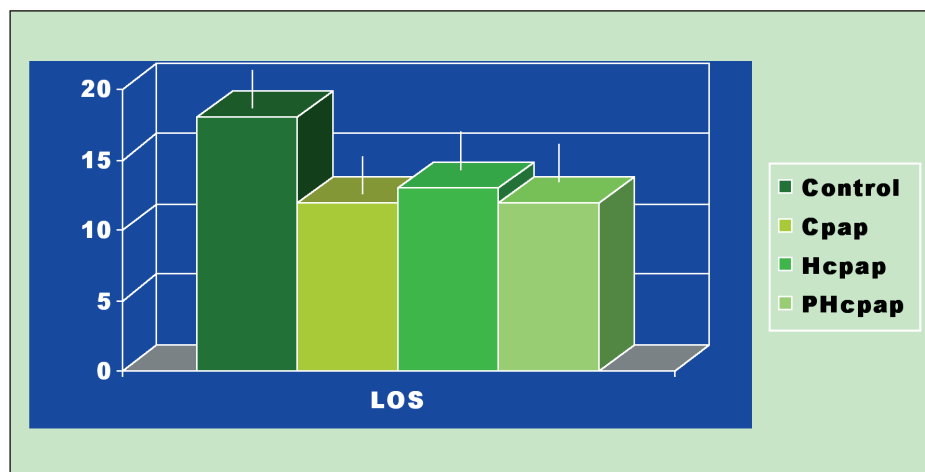

Fig. 3. - Mean Length of Stay (LOS) for controls, Hospital CPAP (Hcpap) patients and Pre Hospital CPAP (PHcpap) patients. Differences between control group and each of the other three groups were significant: p<0.0001.

must be underlined that the PHCPAP was the group with less pneumonia and AECOPD cases and more ACPE patients, a condition representing the optimal indication for CPAP. Anyway, to study in-hospital mortality we used multiple logistic regression, which analysing the independent effect of each variable on the outcome, allowed comparisons between groups even if they differed significantly at the baseline.

Thus, even if lack of randomisation and comparison with a historical control group means that caution should be used when interpreting the results, it would seem that CPAP, in general has a positive impact on physiologic variables, such as lung gas exchange, acid-base balance, heart rate, respiratory rate, and blood pressure, as has been found in previous studies [16, 17].

Several studies have reported on the efficacy of CPAP on acute respiratory failure [18]; a very effective application was on the out-of-hospital treatment of patients with pulmonary oedema [19]. The tertiary objective of this study was to evaluate whether the application of out-of-hospital CPAP is a feasible treatment for ARF of any cause (not only acute pulmonary edema). For this reason, we enrolled patients with ARF of different cause, and in the regression analysis we took diagnosis of admission into account.

Some articles have reported possible negative consequences of a re-breathing effect on CO_2 retention, casting doubts about the application of a helmet to patients with hypercapnia or at risk of hypoventilation [20, 21]. Probably, its use for brief periods of time (<1 hour) does not produce negative effects on the prognostic course of the illness.

Larger studies are recommended to confirm this apparent benefit of ambulance use of CPAP.

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