Prevalence and prognostic role of cardiovascular complications in patients with exacerbation of chronic obstructive pulmonary disease admitted to Italian respiratory intensive care units

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Background. **Cardiovascular complications are frequently observed in patients with chronic obstructive pulmonary disease (COPD) admitted to respiratory intensive care units and may affect the prognosis. The aims of this study were to evaluate a) the prevalence of cardiovascular complications in patients with COPD exacerbation admitted to respiratory intensive care units, b) which parameters detected at admission were predictive of cardiovascular complications, and c) the prognostic role of cardiovascular complications.**

Methods. **A series of 278 consecutive patients with COPD admitted to 11 Italian respiratory intensive care units between November 1997 and January 1998 has been retrospectively analyzed. All cardiovascular complications were recorded.**

Results. **One hundred and ten patients (39.6%) developed cardiovascular complications: congestive heart failure 49 (17.6%), arrhythmias 40 (14.4%), shock 13 (4.7%), and hypotension 11 (4%). Multivariate analysis showed that the APACHE II score, ECG abnormalities (supraventricular ectopic beats, right and/or left ventricular hypertrophy) and digoxin therapy were independent predictors of cardiovascular complications. The overall mortality was 9% being 4.7% in patients without and 15.5% in patients with cardiovascular complications (p = 0.0044). Multivariate analysis showed that the APACHE II score, respiratory rate, pneumonia and end-stage respiratory diseases were independent predictors of mortality.**

Conclusions. **Cardiovascular complications occurred in many patients with COPD exacerbation admitted to respiratory intensive care units, and identify a subset of patients with higher mortality.**

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Introduction

Patients admitted to respiratory intensive care units (RICUs) with exacerbation of chronic obstructive pulmonary disease (COPD) are at risk of cardiovascular comorbidities and/or cardiovascular complications (CVCs)[1-8]. Coexisting cardiovascular diseases (particularly coronary artery disease and left ventricular dysfunction)[1,2,7,8], heart-lung interactions during acute respiratory failure[9-12] and cardiovascular effects of hypoxemia, hypercarbia, electrolyte imbalance, drug and physical therapy, mechanical ventilation, sleep-disordered breathing[1-12] are possible causes of CVCs in these patients. Several CVCs such as cardiac arrhythmias, heart failure and cardiogenic shock require additional clinical and ECG monitoring and specific management.

In recent years, European[13] and Italian surveys[14] have shown a growing interest in the organization of RICUs.

In this study we have collected data from 11 of the 26 Italian RICUs involved in a large retrospective study in order to evaluate: a) the prevalence of CVCs in patients with exacerbation of COPD admitted to RICUs; b) which parameters detected at admission were predictive of CVCs; and c) the prognostic role of CVCs.

Methods

We retrospectively examined 278 patients with exacerbation of COPD as de-

fined by the American Thoracic Society[15] and consecutively admitted to 11 Italian RICUs between November 1997 and January 1998.

The study aims and which parameters were to be retrospectively collected were discussed during three meetings held in 1998 and 1999 by the Writing Group on Respiratory Intensive Care of the Italian Association of Hospital Pneumologists (AIPO). Out of the 26 Italian RICUs involved in a recent census and prospective cohort study[14], 11 agreed to participate in the present study. The coordinating Center arranged and offered the software for collecting the study data regarding demographics and anthropometrics, clinical history, respiratory disease, previous pulmonary function tests obtained when the patient was clinically stable, comorbidities, cause(s) of exacerbation, physical examination, arterial blood gas analysis, serum electrolytes, creatinine, APACHE II score[16], chest X-ray, and ECG. Moreover, during hospitalization, data regarding drug and oxygen therapy, the use of mechanical ventilation (either invasive or non-invasive) and the occurrence and evolution of CVCs were gathered. The length of RICU stay and cause of death were recorded. Other issues covered included:

• associated respiratory diseases: bronchiectasis, interstitial lung disease, kyphoscoliosis, obstructive sleep apnea, pleural effusion, postoperative patients, asthma, pneumonia, post-tuberculosis thoracic disease, neuromuscular diseases, pulmonary embolism, pneumothorax, acute respiratory distress syndrome, known pulmonary hypertension/chronic cor pulmonale (evaluated using a pulmonary artery catheter or by means of echocardiography or ECG), and other basal respiratory diseases;

• comorbidities: hypertension, previous myocardial infarction, valvular heart disease, cardiac arrhythmias, chronic renal failure, cancer, coronary artery disease, congestive heart failure, diabetes mellitus, and chronic liver disease;

• causes of exacerbation: bronchopulmonary infection, acute heart failure, severe cardiac arrhythmias, pulmonary embolism, pneumothorax, metabolic disorders, end-stage respiratory disease, and others.

CVCs developing during the RICU stay were defined as follows:

- acute heart failure: symptoms and signs of heart failure (new-onset or worsening dyspnea, orthopnea, paroxysmal nocturnal dyspnea, lower extremity edema, jugular venous distension, respiratory rales) in patients with known heart diseases, supported when possible by chest X-ray or echocardiography[17];
- severe cardiac arrhythmias: as defined by Chou[18];
- hypertensive crises: a rapid increase in the diastolic arterial pressure (> 120 mmHg) with or without symptoms or signs of organ damage (retinal bleeding or exudates, papilledema, heart failure, angina, etc.)[19];
- myocardial ischemia: new appearance of ECG abnormalities with or without symptoms of angina[20];
- myocardial infarction: new appearance of Q waves on the ECG with elevation of the serum levels of cardiac enzymes with or without symptoms[21];
- severe hypotension: systolic arterial pressure < 90 mmHg;
- cardiovascular shock: systolic arterial pressure < 90 mmHg with signs of organ hypoperfusion (impaired consciousness, clammy and cold skin, diuresis < 20 ml/hour);
- deep vein thrombosis: recent-onset unilateral pain and/or swelling above or below the knee; erythema, warmth and superficial thrombophlebitis with a palpable tender cord and/or diagnostic contrast venography or ultrasonography[22];
- pulmonary embolism: according to guidelines[22,23].

Statistical analysis. Patients were classified according to the development of CVCs (see previous definition) and mortality. Multivariate logistic regression models were used to determine the association between the parameters found on admission and CVCs and between the same parameters or CVCs and mortality. Patients referring shock have not been considered in the logistic model on exitus. The statistical significance of each factor has been tested in the logistic model by means of the Wald χ^2 test. The odds ratios and confidence intervals have been provided in order to assess the sign and magnitude of the relationships. All statistical analyses have been performed using the SAS System version 8 (SAS Institute Inc., Cary, NC, USA).

Results

During a 3-month period, 340 patients were admitted to the 11 RICUs participating in the survey and 278 of them (81.7%) presented with exacerbation of COPD.

The clinical characteristics and the associated chronic respiratory diseases of the 278 COPD patients admitted to the RICUs are shown in table I. Ninety pa-

Table I. Clinical characteristics and chronic respiratory diseases in 278 patients with chronic obstructive pulmonary disease admitted to 11 Italian respiratory intensive care units.

Age (years)	71.3 ± 8.2
Male	200 (72%)
Episodes of ARF/patients in the last 2 years	1.5 ± 1.8 (61% ≥ 1)
Patients on LTOT	152 (54.7%)
Patients on HMV	34 (12.2%)
Pulmonary hypertension/CCP	105 (37.8%)
Patients with associated chronic respiratory diseases	188 (67.6%)
Tuberculosis sequelae	37 (13.3%)
Bronchiectasis	11 (4%)
Obstructive sleep apnea syndrome	7 (2.5%)
Kyphoscoliosis	6 (2.2%)

ARF = acute respiratory failure; CCP = chronic cor pulmonale; HMV = home mechanical ventilation; LTOT = long-term oxygen therapy.

tients (32.4%) had COPD without other known associated chronic respiratory diseases, while the remaining 188 patients (67.6%) had one or more associated chronic respiratory diseases. A recent pulmonary function test performed when the patient was clinically stable was available for 127 patients (45.7%) and the main results were (percent predicted ± SD): forced expiratory volume in 1 s (FEV_1) (40 ± 15.9%), forced vital capacity (FVC) (55 ± 16.4%), and FEV_1/FVC ratio (62.5 ± 22.9%). Major comorbidities are shown in table II. The causes (one or more/patient) of exacerbation were: respiratory infection in 191 cases (68.7%), acute heart failure in 74 (26.6%), severe cardiac arrhythmias in 7 (2.5%), end-stage respiratory disease in 7 (2.5%), pulmonary embolism in 4 (1.4%), pneumothorax in 3 (1.1%), and others in 15 (5.4%). The main parameters detected on admission to the RICUs are reported in table III.

At the time of admission chest roentgenographic abnormalities included: pulmonary infiltrates (29%), stasis-edema (32%), cardiomegaly (51%), pleural effusion (14%), tuberculosis sequelae (16%), bullae (9%), and pneumothorax (1%). In the RICUs treatment included: oxygen therapy (90.3%), theophylline (71.6%), diuretics (75.5%), inhalatory $beta_2$-agonists (73.4%), antibiotics (75.9%), digitalis (53.2%), systemic steroids (57.6%), heparin (41%), non-invasive mechanical ventilation (59.7%) (in particular non-invasive positive pressure ventilation 55.4% and iron lung 3.9%), invasive mechanical ventilation (10.8%), ACE-inhibitors (32%), oral anticoagulants (4.7%), nitrates (22.7%), antiarrhythmic drugs (10.8%), and calcium channel blockers (13.7%). The CVCs that occurred are reported in table IV. In order to determine whether the occurrence of CVCs within the RICU was mainly conditioned by preexisting known cardiovascular comorbidities or causes of exacerbation (in particular chronic heart failure and arrhythmias), the 166 patients who had no history of heart failure or cardiac arrhythmias neither as comorbidity nor as a cause of exacerbation were analyzed. Thirty-two percent of them developed CVCs. The CVCs occurring in this subset of patients included arrhythmias in 20 patients (12%), acute heart failure in 17 (10.2%), hypotension in 9 (5.4%), shock in 8 (4.8%), myocardial ischemia in 4 (2.4%), and hypertensive crises in 4 (2.4%). The overall in-hospital mortality was 9% (25 patients). With regard to patients with CVCs, the mortality was 15.5%, significantly higher ($p = 0.0044$) than for those without CVCs (4.7%). The in-hospital mortality according to the CVC was 76.9% for shock, 27% for hypotension, 12.5% for arrhythmias, 12.5% for hypertensive crises, and 12.2% for heart failure. On average, the patients died 14.1 ± 16 days (range 1-64 days) after admission. The causes of death reported (one or more/patient) were: CVCs in 13 (52%), infections in 9 (36%), multiorgan failure in 6 (24%), and respiratory failure, major hemorrhage, renal failure, sepsis and lung cancer each in 1 patient (4%). Univariate analysis or Fisher's exact test showed that the variables (as evaluated at the time of admission) which were predictive of CVCs ($p < 0.05$) were (mean value in patients with CVCs vs mean value in patients without CVCs and/or p value): older age (72.9 vs 70.5

Table II. Comorbidities reported in the 278 study patients.

≥ 1	235 (84.5%)
Systemic hypertension	72 (25.9%)
Previous myocardial infarction	11 (4%)
Coronary artery disease	46 (16.5%)
Heart failure	58 (20.9%)
Severe arrhythmias	32 (11.5%)
Dilated cardiomyopathy	11 (4%)
Valvular heart disease	10 (3.6%)
Diabetes mellitus	34 (12.2%)
Chronic renal failure	11 (4%)
Chronic liver disease	9 (3.2%)
Cancer	20 (7.2%)

Table III. General findings at admission.

Heart rate (b/min)	99.1 ± 19.7
Respiratory rate (breaths/min)	27.2 ± 6.5
Arterial pressure (mmHg)	134/78 (± 22.2/± 12.2)
PaO_2 (mmHg)	56.4 ± 18.6
$PaCO_2$ (mmHg)	68.1 ± 19.3
pH	7.33 ± 0.08
HCO_3	34.5 ± 7.4
APACHE II score	21 ± 7.1
Electrocardiographic findings (%)	
Sinus rhythm	73.7
Atrial fibrillation	12.6
Supraventricular ectopic beats	13.3
Supraventricular tachycardia	2.2
Right ventricular hypertrophy	10.1
Left ventricular hypertrophy	7.2
Right atrial enlargement	18.7
Left atrial enlargement	2.2
Previous myocardial infarction	3.2
Right bundle branch block	15.5
Left bundle branch block	2.5
Others	27

Table IV. Cardiovascular complications that were observed in patients admitted to the respiratory intensive care units.

Patients with cardiovascular complications	110 (39.6%)
Acute heart failure	49 (17.6%)
Severe arrhythmias	40 (14.4%)
Atrial fibrillation	19 (6.8%)
Sustained supraventricular tachycardia	16 (5.8%)
Ventricular fibrillation	2 (0.7%)
Multifocal atrial tachycardia	2 (0.7%)
Non-sustained ventricular tachycardia	2 (0.7%)
Sustained ventricular tachycardia	2 (0.7%)
Cardiogenic shock	13 (4.7%)
Severe hypotension	11 (4%)
Deep vein thrombosis	1 (0.4%)
Pulmonary embolism	2 (0.7%)
Acute myocardial ischemia	8 (2.9%)

years, p = 0.01), fewer episodes of previous acute respiratory failure in the last 2 years (1.1 vs 1.8, p = 0.0009), lower systolic arterial pressure (130.5 vs 137.2 mmHg, p = 0.02), hypercapnia ($PaCO_2$ 71.8 vs 65.8 mmHg, p = 0.01), acidosis (pH 7.31 vs 7.35, p = 0.001), APACHE II score (24.3 vs 19.2, p < 0.0001), heart failure as a comorbidity (p = 0.003) or as a cause of exacerbation (p < 0.0001), stasis/edema (p = 0.01) or pneumothorax (p = 0.009) at chest X-ray, supraventricular ectopic beats detected at ECG (p = 0.0002), right or left ventricular hypertrophy detected at ECG (p = 0.01), and drugs (dopamine, digoxin, systemic steroids, diuretics, antiarrhythmic drugs, heparin). Moreover, multivariate logistic regression analysis (Table V) showed that the APACHE II score, digoxin therapy, supraventricular premature beats and right or left ventricular hypertrophy were all predictive of CVCs. The Fisher's exact test showed that the occurrence of CVCs and, in particular of shock, was strongly predictive of mortality (p = 0.0044 and p < 0.0001, respectively). Finally, the APACHE II score, pneumonia, respiratory rate and end-stage respiratory disease were found to be predictive of in-hospital mortality at multivariate logistic regression analysis (Table VI). Since shock is a pre-terminal condition in itself, patients referring such an event were not included in this logistic model.

Table V. Predictors of cardiovascular complications (multivariate logistic regression analysis).

Variable	Odds ratio	95% CI	p
APACHE II score (> 20)	3.89	2.02-7.45	< 0.0001
Supraventricular premature beats	3.17	1.33-7.51	0.0087
Right or left ventricular hypertrophy	2.63	1.21-5.72	0.014
Digoxin therapy	2.13	1.13-4.08	0.0181
Theophylline therapy	0.30	0.15-0.82	0.0011

CI = confidence interval.

Table VI. Predictors of in-hospital mortality (multivariate logistic regression analysis).

Variable	Odds ratio	95% CI	p
End-stage respiratory disease	32.52	3.62-291.59	0.0019
Pneumonia	12.79	2.81-58.03	0.0010
APACHE II score (> 20)	4.04	1.18-13.81	0.025
Respiratory rate	1.21	1.082-1.374	0.0011

CI = confidence interval.

Discussion

Occurrence of cardiovascular complications in patients admitted to respiratory intensive care units for exacerbation of chronic obstructive pulmonary disease. As reported by other authors[1-3,8,24], this study shows that cardiovascular comorbidities and CVCs are frequent in patients admitted to RICUs with exacerbation of COPD. Several clinical and instrumental variables evaluated at the time of admission identify patients at increased risk of developing CVCs. Finally, patients with CVCs have a significantly increased risk of in-hospital mortality.

Cardiovascular comorbidities such as a history of hypertension, heart failure, coronary artery disease or severe cardiac arrhythmias are found in 11.5-25.9% of patients; in agreement with what reported by Fuso et al.[24] and by Connors et al.[25], in the present study 26.6% of patients presented with heart failure and 2.5% with cardiac arrhythmias. In this study, a high percentage of patients developed CVCs (39.6%); this is possibly due to the fact that exacerbation of COPD with a significant increase in the mean pulmonary arterial pressure may precipitate acute right ventricular failure[1], or left ventricular failure in those with left ventricular hypertrophy (reported in up to 30% of patients with COPD at autopsy)[2,7]. Support to the latter hypothesis is also provided by the finding that a significant left ventricular systolic or diastolic dysfunction at rest is a frequent occurrence in such patients[2,4,8,26,27]. Kohama et al.[7] found a correlation between the severity of fibrosis in the left and right ventricles and suggested that several factors, such as increased plasma epinephrine levels, hypoxia and arterial acidosis, may produce biventricular changes in patients with COPD. Moreover, many factors have been proposed to account for left ventricular dysfunction in patients with COPD, including hypoxemia, acidosis, ventricular interdependence, marked negative swings in the pleural pressure, and occult coronary artery disease[2,28]. A high proportion (16.5%) of our patients had coexisting coronary artery disease. The coexistence of coronary artery disease has been reported in up to 35% of such patients and may explain the frequent development of heart failure in case of exacerbation of COPD[2,8,28]. In patients with exacerbation of COPD characterized by increasing air trapping and dynamic hyperinflation, the intrathoracic pressure fluctuates over a wide range (+20 to -60 cmH_2O) during spontaneous respiratory efforts. These marked negative intrathoracic swings augment the venous return and end-diastolic right ventricular volume which conditions a left shift of the interventricular septum and an increase in the intrapericardial pressure finally altering the left ventricular diastolic function[2,10-12,28]. Moreover, recurrent episodes of exacerbation of COPD with intermittent large changes in the negative intrathoracic pressure may induce left ventricular hypertrophy and finally systolic dysfunction by increasing left ventricular transmural pressure and afterload[12,28]. In patients with acute respiratory failure due to exacerbation of COPD, hypoxemia, hypercapnia, acidosis, alkalosis, hypokalemia, digitalis, methylxanthines, beta-adrenergic

agonists, steroids, coexistent coronary artery disease, left ventricular diastolic dysfunction, sleep-disordered breathing, chronic cor pulmonale, and particularly right heart failure, chest physiotherapy and/or tachycardia, mechanical ventilation may be involved as a cause of arrhythmia[3-6,9,29-31]. In accordance with previous studies[24], even in our series several known risk factors for arrhythmias were present. Nevertheless, our study demonstrates that patients with exacerbation of COPD, even in the absence of known heart failure and arrhythmias, are at high risk of developing CVCs (31.9%). In this study, several variables, as evaluated at the time of admission, were predictive of CVCs. Digoxin therapy is a well-known risk factor for cardiac arrhythmias in patients with respiratory failure, and this condition has been shown to increase the sensitivity to digoxin which correlates with the degree of arterial hypoxemia[3]. Congestive heart failure is a major risk factor for the development of ventricular and supraventricular arrhythmias[32]. A significant percentage of our patients had congestive heart failure as a comorbidity (20.9%) or as a cause of exacerbation of COPD (26.6%), and 17.6% of all these patients developed heart failure during their stay in the RICUs. It has recently been demonstrated that treatment with inhalatory beta$_2$-agonists increases the risk of hospitalization for arrhythmias in patients with cardiac diseases[31]. Although a high percentage (73.4%) of our patients was using these drugs, we did not find any correlation with the development of CVCs. The APACHE II score is used to determine the severity of illness in critical care patients[16]. In this study, the APACHE II score was found to be a strong predictor of CVCs (Table V), confirming the results of previous studies[3,6]. The diagnosis of right ventricular hypertrophy at standard ECG is highly specific, but has a low sensitivity especially in COPD patients[33].

This study shows a strong correlation between ECG evidence of right or left ventricular hypertrophy at the time of admission and the development of CVCs (CVCs developed in 51 and 63% of patients respectively with right or left ventricular hypertrophy). It has recently been reported that right ventricular hypertrophy and chronic cor pulmonale (particularly the S1S2S3 pattern and right atrial overload) are strong predictors of death in COPD patients discharged after an acute exacerbation[34,35]. Even the presence of left ventricular hypertrophy identifies a subset of patients with a significantly increased risk for cardiovascular morbidity and mortality[36]. The predictive role of right and left ventricular hypertrophy in the development of CVCs confirms the high risk of such events in COPD patients with structural heart diseases[1,2,33,36]. We think that the surprisingly strong inverse correlation found between theophylline therapy and the development of CVCs may be due to the habit of not treating patients with cardiovascular comorbidities and/or previous CVCs with this drug owing to its well known pro-arrhythmic effects[3].

Prognostic factors in patients with exacerbation of chronic obstructive pulmonary disease and the impact of cardiovascular complications. In the present series, the overall in-hospital mortality was 9%, but for patients with one or more CVCs it was 15.5%. In particular, the highest mortality rate was noted in patients who had developed shock (76.9%). Our in-hospital mortality is similar to that reported in the SUPPORT trial (11%), in which more than 1000 patients with severe hypercarbic COPD exacerbations were studied[25]. The severity of the acute event, chronic health state, nutritional status and the presence of cardiac disease were the variables associated with death at 6 months (33%)[25]. Fuso et al.[24] evaluated 590 patients hospitalized for worsening COPD with acute respiratory failure. At logistic regression analysis, age, an alveolar-arterial oxygen gradient > 41 mmHg, ventricular arrhythmias and atrial fibrillation were the baseline variables related to in-hospital mortality (14.4%). Seneff et al.[37] described the outcomes and identified the variables associated with the in-hospital and 1-year survival of the 362 patients admitted to an intensive care unit for an acute exacerbation of COPD. The overall in-hospital mortality was 24%, increasing to 30% for patients aged ≥ 65 years. At multiple regression analysis, the variables predictive of in-hospital mortality were age, severity of respiratory and non-respiratory system dysfunction and the length of hospitalization before admission to an intensive care unit[37]. The development of non-respiratory organ system dysfunction was the major predictor of in-hospital mortality.

In the present study, the independent prognostic variables were similar to those reported by other authors: a) the APACHE II score (integrating the severity of the acute event, in particular cardiorespiratory function, age, and the severity of chronic illness); b) the severity of respiratory dysfunction (respiratory rate, end-stage respiratory disease as the cause of exacerbation); c) pneumonia as the cause of exacerbation[24,25,37,38]. As in the present study the presence of pneumonia has been reported to be the most important predictor of mortality in patients with severe COPD[38].

Study limitations. This study is retrospective and refers to a part of the patients (278 of 756) included in a previous prospective cohort study[14]. The characteristics of our patients are similar to those reported in the prospective cohort study, but only COPD patients, who represented 59% of all patients admitted to the RICUs[14], were studied. Heart failure (6.6%) and arrhythmias (6.6%) were among the possible complications reported in the prospective study. The higher percentage of CVCs in this study compared with the prospective study may be due to: 1) the different population (only COPD patients vs all patients admitted to the RICUs), 2) a more careful search for CVCs (a checklist for the detection of possible CVCs was prepared). Despite some differences between the two studies, the reported

outcomes are similar (in-hospital mortalities equal to 9 and 12.6% respectively). Probably, the retrospective nature of our study may have led us to underestimate the real frequency of CVCs, but the characteristics and comorbidities of our patients are very similar to those reported in prospective studies including larger populations[24,25,37]. Moreover, our patient population was admitted to 11 RICUs distributed in different regions of the country. For this reason, it may reasonably be presumed that it represents a reliable sample of the patients with exacerbated COPD admitted to Italian RICUs in daily clinical practice.

Which is the cardiologist's role in the management of these patients? Consultant cardiologists and respiratory intensive care physicians managing patients with exacerbation of COPD admitted to RICUs should have a clear and detailed understanding of the multiple and complex interactions between the cardiovascular and respiratory systems in this clinical scenario[1-12,28,39]. The fundamental concept is that in COPD, the cardiorespiratory unit loses a progressively increasing proportion of its natural reserve and the system becomes less flexible in adapting to the insults of COPD exacerbation. In this situation the heart is more vulnerable to intrathoracic events[28]. In case of exacerbation of COPD, it is very important to recognize and treat the multiple risk factors for the development of CVCs:

• cardiovascular comorbidities, particularly coronary artery disease and heart failure[1,2,7,8];

• heart-lung mechanical interactions during acute respiratory failure in COPD patients[9-13];

• hypoxemia, hypercarbia, electrolyte imbalance, drug therapy, physical therapy, mechanical ventilation, and sleep-disordered breathing[3-6,8-12].

This study shows that simple clinical and ECG data obtained at the time of admission (digoxin therapy, the APACHE II score, ectopic supraventricular beats, right or left ventricular hypertrophy diagnosed at ECG) identify patients at an increased risk of developing CVCs. Many authors claim that non-invasive cardiac evaluation, including transthoracic and, in selected cases, transesophageal echocardiography, significantly improves the management of these patients[39-41].

In conclusion, this study including patients with acute or chronic respiratory failure due to exacerbation of COPD admitted to Italian RICUs shows:

• frequent cardiovascular comorbidities and CVCs, particularly heart failure, supraventricular and ventricular arrhythmias, shock and hypotension;

• clinical and ECG variables evaluated at the time of admission, such as digoxin therapy, the APACHE II score and ECG findings (ectopic supraventricular beats, right or left ventricular hypertrophy) may identify patients at an increased risk of developing CVCs;

• patients with CVCs have an increased risk of in-hospital mortality.

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Appendix

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