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Patients' characterization, hospital course and clinical outcomes in five Italian respiratory intensive care units

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Abstract *Background:* Respiratory intensive care units (RICU) dedicated to weaning could be suitable facilities for clinical management of “post-ICU” patients. *Methods:* We retrospectively analyzed the time course of patients' characteristics, clinical outcomes and medical staff utilization in five Italian RICUs by comparing three periods of 5 consecutive years (from 1991 to 2005). *Results:* A total of 3,106 patients (age 76 ± 4 years; 72% males) were analyzed. The number of co-morbidities per patient (from 1.8 to 3.0, $p = 0.05$) and the previous intensive care unit (ICU) stay (from 25 to 32 days, $p = 0.002$) increased over time. The doctor-to-patient ratio significantly decreased over time (from 1:3 to 1:5, $p < 0.01$), whereas the physiotherapist-to-patient ratio

mildly increased (from 1:6 to 1:4.5, $p < 0.05$). The overall weaning success rate decreased (from 87 to 66%, $p < 0.001$), and the discharge destination changed ($p < 0.001$) over time; fewer patients were discharged to home (from 22 to 10%), and more patients to nursing home (from 3 to 6%), acute hospitals (from 6 to 10%) and rehabilitative units (from 70 to 75%). The mortality rate increased over time (from 9 to 15%). Significant correlations between the doctor-to-patient ratio and the rates of weaning success ($r = 0.679$, $p = 0.005$), home discharge ($r = 0.722$, $p = 0.002$) and the RICU length of stay (LOS) ($r = -0.683$, $p = 0.005$) were observed. *Conclusions:* The clinical outcomes of our units worsened over 15 years, likely as consequence of admitting more severely ill patients. The potential further negative influence of reduced medical staff availability on weaning success, home discharge and LOS warrants future prospective investigations.

Keywords Prolonged weaning · Respiratory intermediate care units · Non-invasive ventilation · COPD

Introduction

Severe chronic respiratory failure (CRF) patients may frequently require intensive care unit admission in order to overcome severe episodes of acute-on-chronic respiratory failure (ACRF) with ventilatory assistance [1]. However, ICUs are expensive resources [2]. Whereas only 40% of patients with ACRF in the ICU need invasive ventilation, they may be treated with non-invasive ventilation (NIV) [3] or need prolonged stay due to difficult weaning [4–6].

Furthermore, in the last years new technologies and improved levels of care have increased the number of “survivors of catastrophic illness” in the ICU, often requiring prolonged weaning [4].

Intermediate care units are expected to relieve congestion of ICUs, to maintain a high level of nursing assistance, to manage patients with ACRF needing NIV, to provide a multidisciplinary rehabilitative approach and to serve as bridge to home-care programs or long-term care facilities [7–9].

We therefore analyzed patients’ characteristics, main clinical outcomes and staff utilization in five respiratory intensive care units (RICU) of northern Italy over 15 years. We also analyzed whether changes in medical staff availability over time influenced major clinical outcomes.

Methods

We retrospectively reviewed medical records from five RICUs from northern Italy. Patients’ records were taken from electronic databases and hospital registers of the Salvatore Maugeri Foundation in Gussago-Lumezzane, Pavia, Veruno, and Montescano, and in Villa Pineta Hospital, Gaiato. Since individual patients’ data were not available, we analyzed mean annual rates of all variables.

Patients

Patients admitted between 1990 and 2005 with the following characteristics were recorded: (1) difficult weaning with tracheostomy after previous ventilation longer than 15 days in the ICU; (2) acute respiratory failure (ARF) needing NIV from our rehabilitative units, presenting with acute deterioration in neurological status, severe hypercapnia with respiratory acidosis and tachypnoea.

Mechanical ventilation (invasive or non-invasive) was adopted according to the previously described criteria [10, 11]. Patients admitted for difficult/prolonged weaning were managed according to previously described protocols [12–14].

Patients were grouped into three categories: chronic obstructive pulmonary disease (COPD) [15], cardiovascular diseases (CVD), including congestive heart failure, post-cardiac surgery sequelae, pulmonary edema and neurological and neuromuscular diseases (NNMD), including post-stroke, Guillain-Barré syndrome, tetraplegia, Duchenne dystrophy and amyotrophic lateral sclerosis.

Setting

Our five RICUs belong to multidisciplinary respiratory rehabilitation units and receive patients from regional hospitals, with an overall number of beds ranging between 10 and 28. Respiratory assistance (including physiotherapy), speech and swallowing services were available. Intensivists or pneumologists trained in mechanical ventilation served as primary physicians.

Measurements

Age, gender, admission diagnoses, Acute Physiology and Chronic Health Evaluation (APACHE-II) score, chronic co-morbidities (including peripheral vascular, cerebrovascular, coronary artery and chronic lung diseases, active cancer, acquired immunodeficiency syndrome, hepatic cirrhosis or diabetes) and previous length of stay (LOS) in the ICU of origin were collected.

We evaluated the medical staff availability through nurse, physiotherapist, and doctor-to-patient ratios. RICU bed availability for the regional population was also registered over the years.

Clinical outcomes were: (1) respiratory status (ventilator dependence, spontaneous breathing with or without tracheostomy), (2) RICU LOS, (3) location after discharge (home, nursing-home, rehabilitation hospital, acute-care hospital), (4) in-hospital and 3-month mortality and (5) need of home mechanical ventilation. Successful weaning was defined as the ability to breathe spontaneously for >7 consecutive days.

Statistics

Data are presented as mean \pm SD or proportions of the mean annual rates of variables. Statistical significance was set at $p < 0.05$.

Comparisons were done among the three consecutive 5-year periods of time with one-way repeated analysis of variance (ANOVA) for quantitative variables and chi-square test for qualitative variables. The Bonferroni test was used for post hoc comparisons.

We correlated by Pearson’s test the major clinical outcomes (annual mean rates of in-hospital and 3-month mortality, home discharge and weaning success, LOS)

with patients' age, number of co-morbidities, APACHE-II score, previous ICU stay and medical staff resources (doctor, nurse and physiotherapist-to-patient ratios) in the 15 single-year periods of time.

Results

Patients

During the observational period, 3,106 consecutive adult patients were analyzed (Table 1); 2,016 (66%) underwent a weaning protocol for prolonged mechanical ventilation (PMV), and 1,090 patients (33%) needed monitoring or NIV treatment for severe ARF.

Demographic characteristics and all indices of functional status did not change over time except the number of co-morbidities and the previous ICU stay that increased over time (Table 1). The proportion of NNMD increased and the proportion of cardiovascular disease decreased over time ($p < 0.001$), while COPD remained constant.

Settings

The number of available beds increased over time, with a constant occupation rate of 97%. The doctor-to-patient ratio decreased over time, whereas the physiotherapist-to-patient ratio increased; the nurse-to-patient ratio remained stable (Table 1).

The RICU beds to the general population ratio increased over time ($p = 0.001$).

Clinical outcomes

The LOS ($p = 0.004$) and in-hospital mortality ($p = 0.049$) increased, and the weaning success rate ($p < 0.001$) decreased over time (Table 2). These outcomes in the three specific subgroups of patients showed trends similar to the overall population.

The discharge destination changed along time ($p < 0.001$), with fewer patients discharged home and an increasing trend of transfer to acute hospitals, rehabilitative units or nursing homes (Table 2). Among the patients discharged at home, we observed an increasing proportion of ventilator dependence by tracheostomy and NIV.

We found significant correlations between the doctor-to-patient ratio and the rates of weaning success ($r = 0.679$, $p = 0.005$), home discharge ($r = 0.722$, $p = 0.002$) and the RICU LOS ($r = -0.683$, $p = 0.005$), but not with mortality. The nurse and physiotherapist-to-patient ratios did not correlate with any outcome variable.

Discussion

Patients

The complexity of our patients increased over time, as demonstrated by the longer previous ICU stay, and higher number of co-morbidities and of proportion of NNMD subjects. The greater number of "chronically critical patients" surviving catastrophic illnesses and the transfer of more severe patients from nearby ICUs due to greater

Table 1 Patients' characteristics, RICU occupation and medical staff of the five RICUs: mean values of the 5-year periods for the overall population

	1991–1995	1996–2000	2001–2005	<i>p</i> Value
Age (years)	78 ± 1	76 ± 4	73 ± 5	n.s.
APACHE-II	13 ± 1	13 ± 1	14 ± 1	n.s.
Previous ICU stay (days)	25 ± 1	28 ± 2	32 ± 3*	0.002
Comorbidities (<i>n</i>)	1.8 ± 0.8	2.6 ± 0.5	3.0 ± 0.6	0.050
Admission diagnosis [<i>n</i> (%)]				<0.001
COPD	574 (64)	705 (72)	789 (65)	
CVD	206 (23)	165 (17)	215 (18)	
NNMD	126 (14)	116 (12)	210 (17)	
Total number of beds (<i>n</i>)	12 ± 2	15 ± 1	24 ± 6*	0.001
Total admissions/year (<i>n</i>)	180 ± 14	197 ± 22	244 ± 45*	0.016
No. of patients/bed/year	15 ± 2	13 ± 1	10 ± 1*	0.002
Nurse-to-patient ratio	1:2.6	1:2.2	1:2.4	n.s.
Physiotherapist-to-patient ratio	1:6.0	1:6.5	1:4.8	0.048
Doctor-to-patient ratio	1:3.3	1:5.1*	1:4.9*	0.001
RICU beds/general population	1:1,410,000	1:1,125,000	1:750,000*	0.001

Data are expressed as mean of annual rates of the five RICUs; descriptors of medical staff availability refer to the first run
ICU Intensive care unit, *COPD* chronic obstructive pulmonary disease, *CVD* cardiovascular disease, *NNMD* neurological and neuromuscular diseases, *RICU* respiratory intermediate care unit

* Post hoc Bonferroni test versus the first period, *p* value <0.01. No significant differences were observed between the second and the third periods of time in any variable

Table 2 Time course of clinical outcomes of the five RICUs: mean values of the 5-year periods for the overall population

	1991–1995	1996–2000	2001–2005	<i>p</i> Value
Length of RICU stay (days)	23 ± 4	30 ± 4*	32 ± 3*	0.004
In-hospital mortality rate [<i>n</i> (%)]	82 (9)	138 (14)	184 (15)	0.049
Three-month mortality [<i>n</i> (%)]	90 (11)	119 (14)	152 (14)	n.s.
Weaning success rate [<i>n</i> (%)]	486 (87)	493 (74)	524 (66)	<0.001
Discharge destination [<i>n</i> (%)]				<0.001
Home	178 (22)	125 (15)	104 (10)	
Nursing home	21 (2)	36 (4)	48 (5)	
Acute Hospital	47 (6)	95 (11)	103 (10)	
Rehabilitative unit	573 (70)	591 (70)	780 (75)	
Respiratory status of patients discharged at home [<i>n</i> (%)]				<0.001
Home ventilation by tracheostomy	22 (12)	32 (25)	34 (33)	
Home NIV	8 (4)	7 (6)	11 (11)	
No ventilatory support	149 (84)	87 (69)	59 (56)	

Data are expressed as mean of annual rates of the five RICUs; length of stay is expressed as mean no. of days ± SD
 RICU Respiratory intermediate care unit, NIV non-invasive ventilation

* Post hoc Bonferroni test versus the first period, *p* value <0.005. No significant differences were observed between the second and the third periods of time in any variable

experience of our RICU staff may explain these changes in part. Moreover, the advances in respiratory and neurological physiotherapy, and the diffusion of home MV programs can justify the increased admission of NNMD patients to RICU facilities.

Settings

The RICU bed availability in Northern Italy has progressively increased over time. However, the ideal number of beds per population for a RICU dedicated to prolonged weaning, about 1/200,000 in Europe, is largely higher than in our regions (Table 1) [7]. Therefore, a further increase in RICU beds is needed to reduce ICU workload and reinforce cost-saving services such as home-care programs.

In addition, we found a progressive decrease in the doctor-to-patient ratio as a consequence of hospitals' fund-saving decisions because of the lack of a clear national reimbursement policy; however, its efficacy is unclear since prolonged stay in ICUs causes a considerable increase in costs.

The association between ICU physician staffing and clinical outcomes has been studied. A systematic review showed lower mortality and LOS with high-intensity physician staffing [16]. Dara and Afessa [17] observed a longer stay during the periods with fewer intensivists in a medical ICU. Similarly, we found a correlation between fewer physicians and worse LOS, weaning success and home discharge, but not with mortality. However, it is worth noting that the statistical strength of our finding is low due to the inability to perform a deeper analysis with available data.

Clinical outcomes

There is great variability in the clinical outcomes of weaning centers in the literature [7]. Weaning success, ranging from 10 to 92% [7], seems strongly related to hospital organization such as the existence of dedicated ventilator units able to improve weaning success [18], patients' autonomy and families' preparation for home discharge with ventilation [19].

Similarly, hospital mortality [7] and LOS [20] are widely variable. Staff expertise and the learning effect could also explain this variability in clinical outcomes of weaning centres [21]. Improved methods of prevention and management of respiratory complications were shown to decrease mortality dramatically over time [22, 23]. By contrast, despite increasing expertise in weaning care, the main outcomes progressively worsened over time in our units. Potential reasons for this would include increased severity of patients as suggested by the higher number of comorbidities, longer stays in ICUs and RICUs and worse mortality rates. Consequently, the proportion of patients discharged without ventilatory support and, in general, discharged at home were lower than in other published series [21, 24]. However, the information on home discharge rate among RICUs is variable, mainly depending on the variability of local weaning procedures and home-care programs. The different diagnoses at admission, the increasing severity of patients, with reduced weaning success rates, and the encouragement/improvement of home-care programs for unweanable patients may all explain these findings [25, 26].

A lower doctor-to-patient ratio correlated with worsening in the weaning success rate, home discharge and LOS in this study. Unfortunately, the lack of individual

patients' information impeded a complete statistical analysis of other potential confounding factors such as changes in case mix and organization of the RICUs. Therefore, despite the fact that a lower availability of doctors in ICUs has been associated with increased LOS [17] and mortality [16], the reliability of the correlations observed in the present study warrants further prospective investigation.

Limitations

The study was conducted retrospectively, and clinical outcomes were taken from hospitals' registers without individual patients' data and long-term mortality. Therefore, the available information regarding pre-morbid functional status and complications during the previous

ICU stay is limited. Moreover, changes in treatment patterns were not systematically registered over the 15-year study period. Finally, the present study was conducted in Northern Italy and may not be representative of other regions.

Conclusion

The clinical outcomes of our units has worsened over 15 years, likely as a consequence of admitting more severely ill patients. The potential further negative influence of reduced medical staff availability on weaning success rate, home discharge and LOS deserves future prospective investigations.

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