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Acute respiratory failure in intensive care units. FINNALI: a prospective cohort study

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Abstract *Objective:* To evaluate the incidence, treatment and mortality of acute respiratory failure (ARF) in Finnish intensive care units (ICUs). *Study design:* Prospective multicentre cohort study. *Methods:* All adult patients in 25 ICUs were screened for use of invasive or non-invasive ventilatory support during an 8-week period. Patients needing ventilatory support for more than 6 h were included and defined as ARF patients. Risk factors for ARF and details of prior chronic health status were assessed. Ventilatory and concomitant treatments were evaluated and recorded daily throughout the ICU stay. ICU and 90-day mortalities were assessed. *Results:* A total of 958 (39%) from the 2,473 admitted patients were treated with ventilatory support for more than 6 h. Incidence of ARF, acute lung injury (ALI) and acute respiratory distress syndrome (ARDS) was 149.5, 10.6 and 5.0/100,000 per year, respectively. Ventilatory support was started with non-invasive interfaces in 183 of 958 (19%) patients. Ventilatory modes allowing triggering of spontaneous breaths were preferred (81%). Median tidal volume/predicted body weight was 8.7 (7.6–9.9) ml/kg and plateau pressure 19 (16–23) cmH_2O. The 90-day mortality of ARF was 31%. *Conclusions:* While the incidence of ARF requiring ventilatory support is higher, the incidence of ALI and ARDS seems to be lower in Finland than previously reported in other countries. Tidal volumes are higher than recommended in the concept of lung protective strategy. However, restriction of peak airway pressure was used in the majority of ARF patients.

Keywords Acute respiratory failure · Acute lung injury · Acute respiratory distress syndrome · Mechanical ventilation · Outcome

Introduction

Acute respiratory failure (ARF) is the most common vital organ failure seen in critically ill patients. Among ICU patients, 40–65% need mechanical ventilation (MV) during their ICU stay [1–4]. As a clinical syndrome, ARF can be related to various acute diseases, and no universally accepted definition exists. Therefore, it is difficult to determine the true incidence of ARF. At the same time, the epidemiology of ARF is important for evaluation of critical care resources.

Most investigations studying the epidemiology of ARF or the application of MV include only a subgroup of ARF patients, namely patients suffering from acute lung injury (ALI) or acute respiratory distress syndrome (ARDS). These syndromes comprise only a minority of all mechanically ventilated patients [1, 5, 6]. Even more importantly, outcome of patients needing MV more than 24 h is comparable with ALI and ARDS patients [5]. Thus, if epidemiological or interventional studies, e.g., regarding low tidal volume (V_t), include only patients with current definitions of ALI/ARDS, important groups of ARF patients are disregarded [7]. Recently, the use of non-invasive techniques of ventilatory treatment has increased, and patients treated with these modalities need to be included in epidemiological study concerning ARF [2].

In this study we evaluate a large, prospective cohort of unselected patients treated with invasive and/or non-invasive treatment for ARF in the ICUs of a defined geographical area. Our aim is to define overall incidence and mortality of ARF. Furthermore, we investigate present treatments and factors related to the mortality. Two abstracts (0657, 0658) of this study were presented at the 21st ESICM Annual Congress, Lisbon, 2008 [8].

Methods

Participating units

All Finnish ICUs were invited to participate in the study. All five University hospitals with 12 ICUs and 13 from 15 tertiary hospital ICUs consented to participate in the study. These ICUs cover the geographical area responsible for more than 97% of the Finnish adult population (4.3 million). All participating ICUs collected the routine dataset of the national ICU quality consortium (The Finnish Quality Consortium, Intensium Ltd., Kuopio, Finland).

Consent from the respective ethics committees was obtained from each hospital. The board of the Quality Consortium approved the study protocol and use of the quality database for the study. Due to established standard of care, the ethics committees waived the need for informed consent for data registration.

Patients

During the 8 weeks (between 16 April and 10 June 2007) all adult patients (≥16 years) admitted to the participating ICUs were screened for the need of respiratory support with any form of positive airway pressure: MV, non-invasive positive pressure ventilation (NPPV) and/or continuous positive airway pressure (CPAP). The non-invasive ventilation (NIV) group includes CPAP and NPPV, although basic differences of these techniques are recognized. The length of study period was estimated a priori with a target of approximately 1,000 patients according to previous epidemiological study [5]. For this study the beginning of ARF was determined as the time when ventilatory support with intubation and/or positive airway pressure was started. The reason for treatment lasting less than 6 h was assessed. If any of these treatments were used over 6 h the study dataset was registered. This moment at 6 h was considered the study baseline. Patients with permanent ventilatory assistance prior to the ICU admission were excluded from the study.

Incidence calculation

ICUs kept a record of all patients needing ventilatory support on admission or during the ICU period in a separate reporting form for crosschecking the number of patients. Social security number (SSN) was used in order to avoid admitting patients repeatedly to incidence calculations. For patients having several episodes of ARF only the first episode lasting over 6 h was taken. The count of the adult population (≥16 years) at the end of year 2006 (31.12.2006) was obtained from Statistics Finland (http://www.stat.fi; accessed 1 December 2007). The adult population of hospital districts of the two non-participating ICUs was subtracted according to data provided by Association of Finnish Local and Regional Authorities (http://kunnat.net; accessed 1 December 2007). The total reference population for incidence calculation was 4,164,980. One-year incidence was estimated based on the incidence during the 8 weeks.

Data collection

The national ICU quality database was used for data collection with an Internet-based interface for reporting clinical report form (CRF) data. A list of data acquired from the quality database and data recorded in the CRF is available in the electronic supplementary material (EMS) appendix. Presence of obstructive and restrictive pulmonary disease, chronic heart disease, diabetes, immune deficiency, neuromuscular disorder and smoking was obtained from the patient history. A relation of alcohol use and ICU admission was assessed according to a

recently published Finnish study [9]. Weight and length were recorded, and predicted body weight (PBW) was calculated according to the formula used in the ARDS network low V_t study [10]. Risk factors 48 h prior to the onset of ARF were gathered, and all existing risk factors per patient recorded. Hemodynamic and ventilatory variables were collected at the baseline and daily thereafter. Concomitant treatments were assessed daily (EMS Table E1). Hospital investigators evaluated lung X-rays when taken. The presence of ALI or ARDS during the ICU stay was evaluated by hospital investigators according to the American–European Consensus Conference (AECC) criteria [7].

If the patient was discharged to another participating ICU and was still treated for the initial reason, the data of these consecutive ICU stays were combined. In addition to incidence calculations, SSN was used for mortality assessment provided by Statistics Finland. Otherwise, the data were managed anonymously with the admission ID. The 90-day mortality was calculated from the beginning of ARF.

Statistical analysis

Continuous data are presented as median with interquartile range (IQR) or mean (±SD). Categorical data are presented as numbers and percentages. The 95% confidence intervals (CI) for incidences were calculated. Non-parametric Mann–Whitney *U* test for continuous data and Fisher's exact test for numbers of events were used for comparisons. Chronic morbidities and risk factors preceding ARF, PaO_2/FiO_2-ratio (PF), SAPS II minus oxygenation points, day 1 SOFA score minus respiration points and ADL status were tested for 90-day mortality in a univariate model. Factors with p value <0.20 were further assessed with a stepwise forward multiple logistic regression analysis, presented as odds ratios with 95% CI for independent variables. Colinearity between the variables was tested. Calibration in an independent data set for the multivariate model could not be done. Discrimination was tested using receiver operating characteristics curve analysis, and accuracy for the final multivariate model was calculated. SPSS 15.0 (SPSS Inc., Chicago, IL) was used for statistical analysis. Due to multiple comparisons a p value ≤0.01 was considered statistically significant.

Results

Included patients

During the 8 weeks (from 16 April to 10 June 2007) a total of 2,670 ICU admissions of 2,473 patients were registered in the participating 25 ICUs. Ventilatory support for ARF was recorded on 1,319 occasions. After excluding ventilatory support less than 6 h (273 patients), multiple inclusions of the same patient (72 patients), foreigners (7 patients) and patients with insufficient data (6 patients), 958 patients with ARF were included in the study (Fig. 1). During the study period, ARF as defined according to our criteria was present in 39% of the patients admitted to the Finnish ICUs.

Patient characteristics and risk factors for ARF

The most common chronic morbidity was chronic heart failure (39%). The most common risk factors 48 h before the onset of ARF were postoperative state (39%), decreased consciousness (30%) and signs of heart failure (20%). Patient characteristics and risk factors according to subgroups non-ALI/ARDS and ALI/ARDS are described in Table 1. Pneumonia, other respiratory infections and sepsis were more often present in ALI/ARDS patients. Of the 958 patients, 300 (31%) received ventilatory support for less than 24 h, and 132 of the 300 (44%) were operative patients. PBW could be calculated for 941 of 958 (98.2%) patients, and it was significantly less than actual body weight (ABW) irrespective of whether measured or estimated. The difference was larger in women than in men, 16.5 (±16.7) and 12.3 (±17.9) kg, respectively.

Overall incidence of ARF

The overall incidence of ARF in Finnish ICUs was estimated to be 149.5/100,000 population per year based on the incidence during the study period. Estimated incidence of patients receiving ventilatory support for more than 24 h was 102.7/100,000 per year.

Incidence of hypoxemic ARF, ALI and ARDS

At baseline, PF ≤300 mmHg (40 kPa) was present with 579 (60%) patients and PF ≤200 mmHg (26.7 kPa) with 310 (32%) patients. During the first 7 days after inclusion, PF ≤300 and 200 mmHg was present with 765 (80%) and 492 (51%) patients, respectively. Incidences of patients fulfilling these ALI and ARDS oxygenation criteria at baseline were 90.4 and 48.4/100,000 per year. However, all clinical and radiological criteria of ALI were fulfilled only in 68/958 (7.1%, 95% CI 4.4–8.8%) patients and accordingly, all diagnostic criteria of ARDS in 32/958 (3.3%, 95% CI 1.7–4.9%) patients. The calculated incidences of ALI and ARDS were 10.6 and 5.0/100,000 per year, respectively.

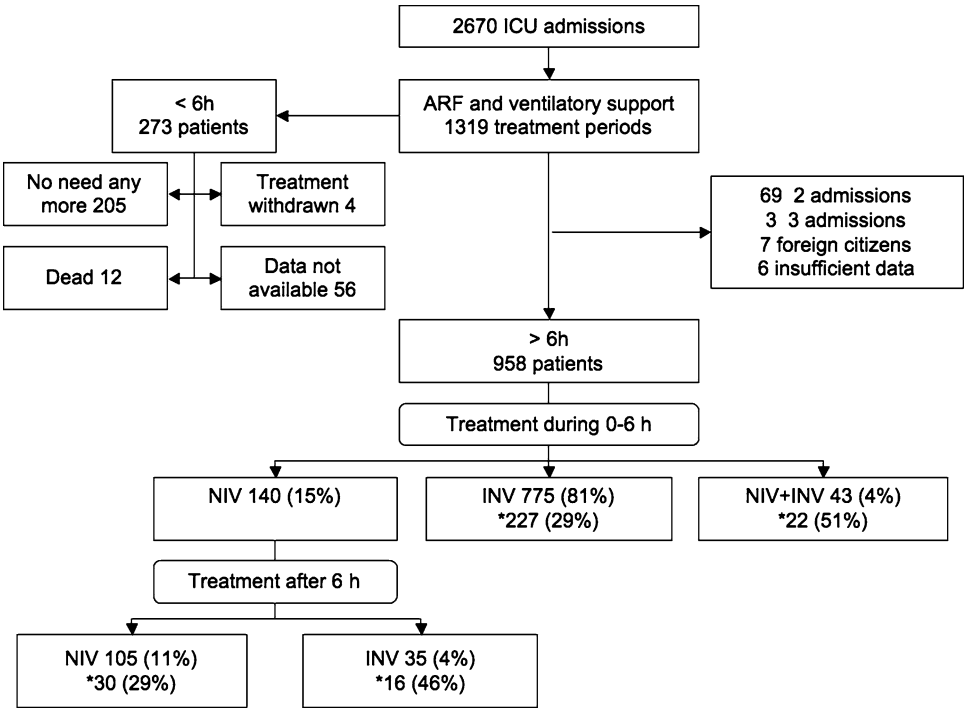

Fig. 1 Patient flow and 90-day mortality (*asterisks*) of the study patients. *ICU* Intensive care unit, *ARF* acute respiratory failure, *NIV* non-invasive ventilation, *INV* invasive ventilation

Ventilatory treatment

Of the 958, 775 patients (81%) were invasively ventilated from the start of ARF (Fig. 1). During the first 6 h, 140 patients (15%) received non-invasive ventilation and 43 patients (4%) both non-invasive and invasive ventilation. Thirty-five more patients were intubated after 6 h of NIV.

Ventilatory, oxygenation and hemodynamic parameters at baseline according to invasive or non-invasive treatment are reported in Table 2 and ESM Table E2. Oxygenation impairment seems to be more severe in the non-invasive groups. Median V_t/ABW was 7.4 (6.2–8.7), while V_t/PBW was 8.7 (7.6–9.9) ml/kg. The difference between mean V_t/ABW and PBW was 1.0 and 2.1 ml/kg in men and women at baseline, respectively (Fig. 2). After baseline V_t/PBW was <7 ml/kg in only 18% of men and 13% of women; 96% of peak airway pressure recordings were <35 cmH_2O in both genders (Fig. 3). Only one patient was ventilated with zero PEEP.

At baseline, pressure and volume controlled ventilation modes (PCV and VCV) were used equally (43 and 47%), while proportion of missing values was 10%. Ventilatory modes allowing triggering of spontaneous breaths were preferred (81%) during the baseline. Controlled mode of ventilation was used only with 9% of the patients.

One hundred seventeen (12%) patients had tracheotomy during their ICU stay. Median time for tracheotomy was 6 (2–10) days. Of 853 invasively ventilated patients, 599 (70%) were extubated, 83 patients (13.9% of 599) were reintubated. The median time to first reintubation was 18 (7–53) h. Twenty patients (24.1% of 83) were reintubated twice after a median of 40 (7–65) h after the second extubation. Prolonged ventilatory support (over 21 days, [11]) was detected in only 32 (3%) of patients. Eighty-two (9%) patients needed ventilatory support at ICU discharge.

Outcome

The 90-day mortalities were 31% (295/958, 95% CI 28–34%) for all ARF patients, 32% (233/658, 29–36%) for patients needing ventilatory support over 24 h, and 47% (32/68), 35–59%) for ALI/ARDS patients. Mortalities in different treatment groups are presented in Fig. 1 and show a tendency to higher mortality in patients who failed NIV.

Difference in non-adjusted mortalities in PF-quintiles is shown in Fig. 4. Of the 958, 808 patients with all available variables could finally be included in the multivariate model. The only independent factors ($p \leq 0.01$) related to the 90-day mortality were baseline SAPS II score minus oxygenation (OR 1.06, 95% CI 1.05–1.08 per one point), chronic heart disease (OR 1.95, CI 1.37–2.77), suspected aspiration in the last 48 h (OR 2.00, CI 1.19–3.39), baseline PF (OR 0.98, CI 0.97–0.99 per 1 kPa) and intoxication (OR 0.32, CI 0.14–0.72). The area under curve for the final multivariate model was 0.81 (95% CI 0.77–0.84), and the accuracy (correct classification rate) was 76.5%.

Table 1 Patient characteristics and risk factors 48 h before ARF

	n	Non-ALI/ARDS 890	*n*	ALI/ARDS 68	*p* value
Age (year)	890	63 (51–74)	68	61 (50–72)	NS
Gender (male)	890	592 (66.5)	68	45 (66.2)	NS
Activities of daily life	881		68		NS
Able to work		455 (51.6)		27 (39.7)	
Unable to work		306 (34.7)		31 (45.6)	
Needs some help		105 (11.9)		8 (11.8)	
Needs help to activities of daily life		15 (1.7)		2 (2.9)	
Underlying co-morbidities					
Obesity (body mass index >35 kg/m^2)	875	73 (8.3)	66	3 (4.5)	NS
Chronic obstructive lung disease	872	144 (16.5)	66	14 (21.2)	NS
Chronic restrictive lung disease	868	36 (4.1)	66	0 (0)	NS
Chronic heart disease	876	347 (39.6)	66	24 (36.4)	NS
Diabetes	874	167 (19.1)	66	12 (18.2)	NS
Immunodeficiency	868	37 (4.3)	66	6 (9.1)	NS
Neuromuscular disease	865	20 (2.3)	66	2 (3.0)	NS
Smoker	735	232 (31.6)	62	27 (43.5)	0.05
Acute or chronic alcohol	854	139 (16.3)	65	22 (33.3)	<0.001
Risk factors 48 h before ARF onset					
Cardiac insufficiency	878	176 (20.0)	67	16 (23.9)	NS
Intoxication	878	69 (7.9)	67	5 (7.5)	NS
Decreased level of consciousness	878	276 (31.4)	67	14 (20.1)	NS
Neuromuscular disorder	875	23 (2.6)	67	2 (3.0)	NS
Operation	877	362 (41.3)	67	15 (22.4)	<0.01
Pneumonia	879	92 (10.5)	67	22 (32.8)	<0.001
Other respiratory infection	875	76 (8.7)	67	14 (20.1)	<0.01
Aspiration, witnessed	879	47 (5.3)	67	7 (10.4)	NS
Aspiration, suspected	878	91 (10.4)	67	10 (14.9)	NS
Sepsis	879	118 (13.4)	67	18 (26.9)	<0.001
Pancreatitis	875	23 (2.6)	67	4 (6.0)	NS
Severe trauma	876	63 (7.2)	67	1 (1.5)	NS
Massive transfusion	877	57 (6.5)	67	3 (4.5)	NS
Variables of the ICU treatment					
SAPS II (points)	890	42 (31–55)	68	43 (35–55)	NS
SOFA (points)	889	8 (6–10)	68	9 (6–11)	NS
SOFA max (points)		9 (6–12)		12 (8–16)	<0.001
SOFA max without respiratory points		7 (4–9)		9 (6–12)	<0.001
Emergency admissions	886	753 (85.0)	68	68 (100)	<0.01
Bilateral infiltrates at baseline	806	158 (19.6)	66	47 (69.1)	<0.001
Ventilatory support (days)	890	2 (1–4)	68	6 (6–11)	<0.001
Length of stay (ICU)	890	3 (2–6)	68	8 (4–13)	<0.001
Length of stay (hospital)	889	11 (6–20)	68	18 (9–36)	<0.001
Treatment restrictions	884	116 (13.1)	67	17 (25.4)	0.005
Mortality (ICU)	890	105 (11.8)	68	15 (22.1)	<0.05
Mortality (30 day)	890	226 (25.4)	68	25 (36.8)	<0.05
Mortality (90 day)	890	263 (29.6)	68	32 (47.1)	<0.01

Patients are divided to subpopulations non-ALI/ARDS and ALI/ARDS. *N* is number of recordings

Values are median (interquartile range) or number (%) as appropriate, statistical comparison made between subpopulations

ARF Acute respiratory failure, *ALI* acute lung injury, *ARDS* acute respiratory distress syndrome

Discussion

Ventilatory support was needed in 1,319/2,670 of ICU admissions (49%), which is comparable to that of previous publications of (43–63%) [1–4]. During the first 6 h, 19% of patients were treated with NIV. This is clearly more than 4 and 11% in two previous studies [5, 12], but comparable to 16 and 23% of two other recent epidemiological studies [13, 14].

Altogether 43% of the patients treated with NIV during the 0–6 h of ARF needed invasive ventilation. Higher than previously reported intubation rates with NIV for acute cardiopulmonary edema [15] and acute exacerbation of COPD [13, 16] may be explained by a small number of patients admitted for these reasons. In Finnish hospitals cardiac care units and in some hospitals respiratory wards treat patients with heart insufficiency, pulmonary edema and exacerbation of COPD with NIV.

Table 2 Ventilatory, oxygenation and hemodynamic parameters of invasive ventilation at baseline

	n	Non-ALI/ARDS 765	*n*	ALI/ARDS 53	*p* value
Respiratory rate, total (1/min)	745	14 (12–16)	51	15 (12–19)	<0.001
Respiratory rate, ventilator (1/min)	720	12 (10–14)	49	13 (12–15)	NS
Controlled ventilation	727	74 (10.2)	52	3 (5.8)	NS
Volume control	731	362 (49.5)	52	20 (38.5)	NS
Pressure control	727	323 (44.4)	51	29 (56.9)	NS
Tidal volume (ml)	683	576 (500–652)	48	544 (460–678)	NS
Tidal volume/actual body weight (ml/kg)	680	7.4 (6.2–8.7)	47	7.5 (6.3–9.0)	NS
Tidal volume/predicted body weight (ml/kg)	676	8.7 (7.6–9.9)	47	8.6 (7.3–9.9)	NS
PEEP (cmH_2O)	711	6 (5–8)	50	8 (6–10)	0.001
Peak airway pressure (cmH_2O)	690	23 (19–27)	47	24 (21–30)	<0.05
Plateau pressure (cmH_2O)	384	19 (16–23)	18	23 (18–27)	<0.05
Mean airway pressure (cmH_2O)	561	11 (9–14)	34	13 (11–16)	<0.001
Compliance, dynamic (ml/cmH_2O)	651	35 (28–45)	46	34 (27–42)	NS
Compliance, static (ml/cmH_2O)	372	45 (36–60)	18	41 (33–56)	NS
PaO_2 (mmHg)	749	109 (87–133)	52	102 (77–121)	0.05
$PaCO_2$ (mmHg)	749	38 (34–43)	52	42 (36–49)	0.001
PH	747	7.39 (7.34–7.44)	52	7.36 (7.30–7.40)	<0.01
FiO_2 (%)	749	40 (35–50)	52	50 (40–65)	<0.001
PaO_2/FiO_2 (mmHg)	745	272 (189–352)	52	200 (138–275)	<0.001
Oxygenation index	559	4.1 (2.7–6.7)	34	5.9 (4.3–14.4)	<0.001
Heart rate (1/min)	755	82 (69–94)	52	84 (72–100)	NS
Mean arterial pressure (mmHg)	752	76 (67–86)	52	71 (64–80)	<0.01
Central venous pressure (mmHg)	568	9 (7–12)	42	9 (7–13)	NS
Pulmonary arterial occlusion pressure (mmHg)	205	12 (10–15)	10	13 (8–16)	NS

Patients are grouped as non-ALI/ARDS and ALI/ARDS. *N* is number of recordings, values are median (interquartile range) or *n* (%)

Our intubation rate is closer to studies of unselected patients and acute hypoxemic respiratory failure [12, 14, 15], which is in line with low baseline PF in our NIV patients.

Our population-based study shows that the incidence of ARF (149.5/100,000 per year) is somewhat higher than the previously reported 77.6–137.1/100,000 per year [5, 17]. The wide variation may result from different study designs and definitions of ARF. When comparing more resembling definitions and patient settings, namely adult patients with intubation and MV (77.6/100,000 per year) [5] to our patients treated with ventilatory support over 24 h (102.7/100,000 per year), the difference diminishes. Using a longer evaluation period, e.g., 24 h, for required treatment decreases the actual incidence of ARF and, thus, markedly underestimates the need for ventilatory support. Therefore, we assessed 6 h to be a clinically relevant time for ventilatory support.

Using current definitions the incidences of ALI and ARDS in Finland seem to be lower than previously reported from other countries [5, 18, 19]. The quite low ALI/ARDS incidence in this study may refer to geographical variation, low genetic predisposition to ARDS, or differences in availability and organization of public health services in different countries. As with ARF, study design also affects ALI/ARDS incidence [20]. Although the AECC definition of ALI/ARDS is widely accepted, all components of the definition have evaluation problems [21–27]. We suggest that the current limit of hypoxemia for ALI in the AECC criteria is high. During the first week in the ICU 80% of our ARF patients fulfilled the oxygenation criteria of ALI. In the previous studies using respiratory SOFA score $\geq$3 (PF <200 mmHg) to determine the prevalence of ARF, patients fulfilling the hypoxemia criteria of ALI have not even been included [3, 4].

The recommendation of low V_t for ALI/ARDS and septic patients has been poorly adopted in clinical practice [10, 28–31]. As low V_t may also benefit patients at risk for ALI/ARDS [32], we were interested in low V_t practice in the whole ARF group. At baseline no significant difference was found in V_t/PBW (8.6 and 8.7 ml/kg) between groups of ALI/ARDS and non-ALI/ARDS. Although larger V_t/PBW in women than men is consistent with the study of Gajic et al. [32], baseline V_ts in our study were lower.

In disagreement with an international evaluation of MV [33], zero PEEP was recorded only once at baseline, and low PEEP very seldom. In addition to the fact that application of at least minimal PEEP may be lung protective, it also reduces the problems of assessing oxygenation impairment with zero or inadequate PEEP [22–24, 34].

The popularity of PCV in Finnish ICUs is in line with previous reports from Scandinavia [5, 35] and may explain the good implementation of airway pressure restriction in our study. Preference for VCV has been reported from several other countries [12, 33].

The 90-day mortality (31%) of our patients is comparable or even lower than in previous epidemiological

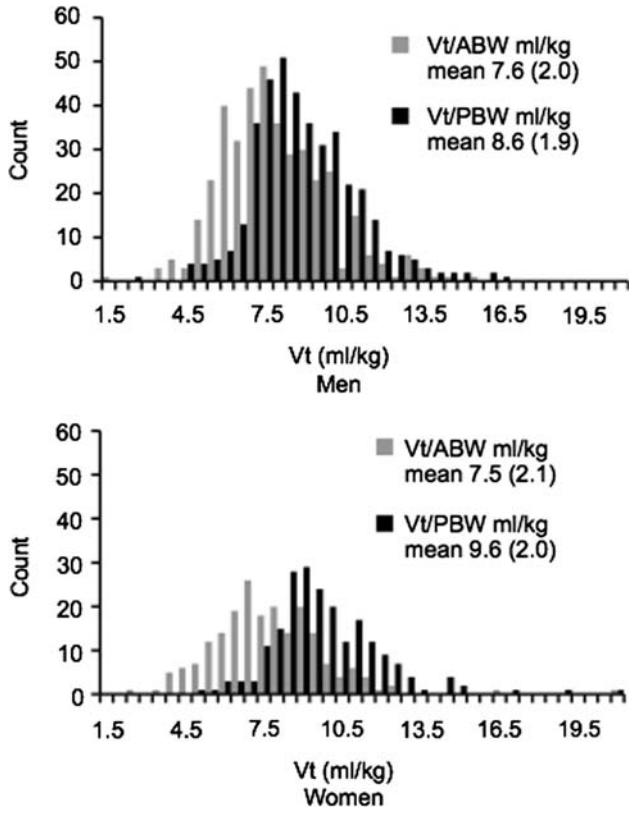

Fig. 2 Tidal volume distribution at baseline (at 6 h after treatment start). V_t Tidal volume (ml/kg), *ABW* actual body weight, *PBW* predicted body weight, values are mean ± SD, PBW men 0.91 × (height − 152.4) + 50, PBW women 0.91 × (height − 152.4) + 45.5 (height in cm)

studies of ARF (36 and 41%) [5, 17]. The 90-day mortality of ALI/ARDS patients (47%) falls between the range (38–60%) of other epidemiological studies [1, 5, 6, 18], but is higher than in selected patients (31%) [10].

In this study baseline oxygenation assessed with PF was independently predictive of 90-day mortality. Association between baseline PF and ICU mortality in ALI/ARDS was reported in a recently published Irish study [36] as well as in the ALIVE study [6]. On the other hand in the ALIVE study and the study of French ICUs, despite differences in ALI and ARDS mortalities (31–33 vs. 58–60%), PF was not independently associated with 28-day or hospital mortality in this subgroup of ARF patients [1, 6]. In general, predictive models are still quite seldom used for longer follow-up, although critical care studies [5, 37] have adopted 90-day mortality as the primary endpoint due to limitations of hospital mortality as an endpoint.

Limitations of the study

Our study has some limitations. First, the study was undertaken in spring months, which may decrease the incidence of airway infections and therefore also the incidence of ARF and ALI/ARDS. Second, according to our study design blood gas values and ventilatory settings were recorded after 6 h of treatment. Therefore, we cannot evaluate the severity of hypoxemia at treatment start time nor treatment effects during the first 6 h. Third, because intermittent use of NIV and preference of ventilatory modes permitting spontaneous breathing are common, ventilatory support was recorded only on a daily basis instead of exact time, and no weaning time was evaluated. In Nordic countries intensivists are responsible for ventilatory treatment, and aim is to minimize the time of ventilatory support. Since weaning actually begins after the start of ventilatory therapy, a rationale for weaning time is obscure. Finally, lack of lung mechanics measurements is a limitation of our study. However, such measurements were not possible to accomplish due to the

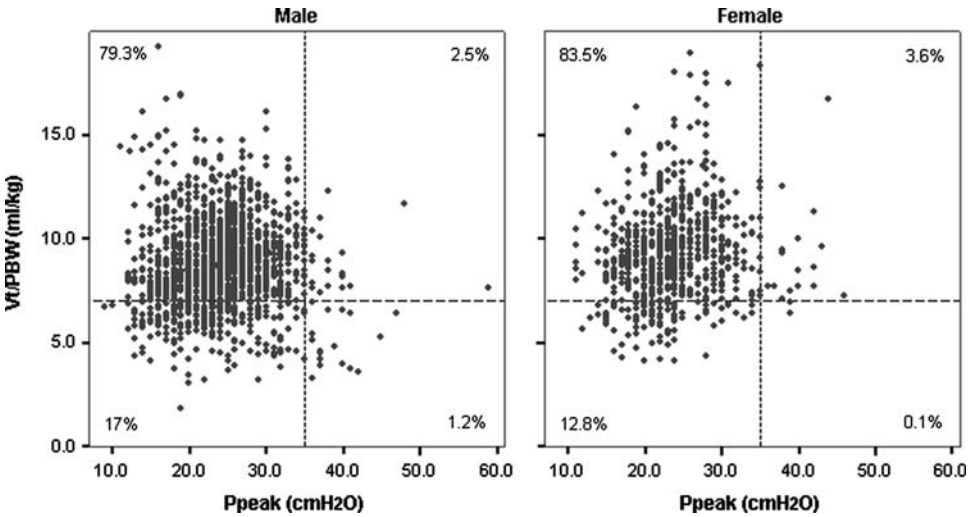

Fig. 3 Tidal volumes plotted against peak airway pressure from day 1 forward. V_t tidal volume, P_{peak} peak airway pressure. Reference lines at P_{peak} 35 cmH_2O and V_t/PBW 7.0 ml/kg

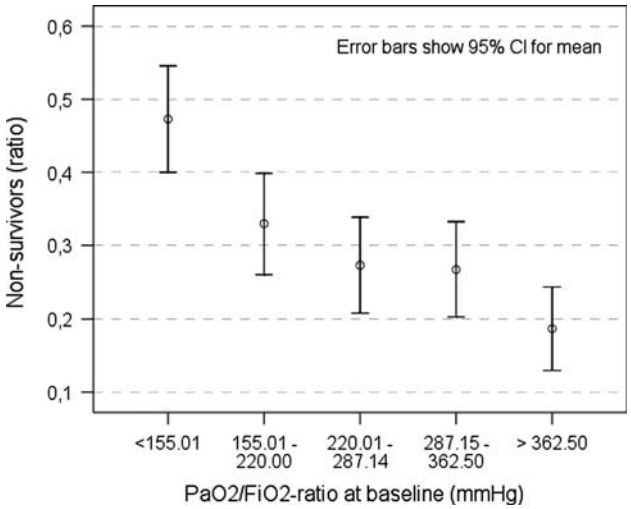

Fig. 4 Non-survivors by day 90 in quintiles of PaO_2/FiO_2-ratio at baseline

epidemiological and descriptive nature of the study and the size of the patient population. Taking into account these limitations, to the best of our knowledge, this is the first nationwide study describing the incidence, treatment and outcome of patients in need of any kind of ventilatory support in the ICUs.

Conclusions

We conclude that ARF treated either with invasive or non-invasive ventilatory support was present in 39% of the patients in Finnish ICUs. ALI and ARDS seem to be less frequent than previously reported, although definitions regarding oxygenation impairment need clarifications. In Finland the concept of low V_t of lung protective strategy is poorly adapted, but airway pressures are widely limited as recommended.

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Appendix

Participating hospitals, investigators (Inv.) and study nurses (SN.) in the FINNALI-study

Satakunta Central Hospital, Dr. Vesa Lund (Inv.), Päivi Tuominen, Pauliina Perkola (SN.); East Savo Central Hospital, Dr. Markku Suvela (Inv.), Sirpa Kauppinen, Anne-Marja Turkulainen (SN.); Central Finland Central Hospital, Dr. Raili Laru-Sompa (Inv.), Tiina Kirkhope, Sirpa Nykänen (SN.); South Savo Central Hospital, Dr. Heikki Laine (Inv.), Kirsi Reponen, Pekka Kettunen (SN.); North Karelia Central Hospital, Dr. Matti Reinikainen (Inv.), Tanja Eiserbeck, Helena Jyrkönen (SN.); Seinäjoki Central Hospital, Dr. Kari Saarinen, Dr. Matti Viitanen (Inv.), Niina Siirilä, Johanna Soini (SN.); South Karelia Central Hospital, Dr. Seppo Hovilehto, Dr. Anne Kirsi, Dr. Pekka Tiainen (Inv.), Sanna Asikainen (SN.); Päijät-Häme Central Hospital, Dr. Pekka Loisa (Inv.); Vaasa Central Hospital, Dr. Pentti Kairi (Inv.); Kanta-Häme Central Hospital, Dr. Risto Puolakka (Inv.), Piia Laitinen, Tarja Heikkilä (SN.); Lappi Central Hospital, Dr. Outi Kiviniemi (Inv.), Tarja Laurila, Tiina Pikkuhookana (SN.); Keski-Pohjanmaa Central Hospital, Dr. Samuli Forsström, Dr. Tadeusz Kaminski (Inv.), Tuija Kuusela (SN.); Kymenlaakso Central Hospital, Dr. Jussi Pentti, Dr. Seija Alila (Inv.), Reija Koskinen (SN.), Helsinki University Hospital, Jorvi Hospital Dr. Tero Varpula (Inv.), Mira Rahkonen (SN.); Meilahti Hospital medical ICU, Dr. Tom Bäcklund, Dr. Juhani Rossinen (Inv.), Riina Mäkelä (SN.); Meilahti Hospital ICU, Dr. Anne Kuitunen, Dr. Anna-Maija Korhonen, Dr. Rita Linko, Dr. Marjatta Okkonen (Inv.), Janne Myller, Jarmo Pekkola, Leena Pettilä, Sari Sutinen (SN.); Meilahti Hospital cardiothoracic ICU, Dr. Raili Suojaranta-Ylinen, Dr. Sinikka Kukkonen (Inv.), Elina Nurmi-Toivonen (SN.); Töölö Hospital, Dr. Janne Reitala, Dr. Jyrki Vuola (Inv.), Raija Niemi, Marja-Leena Pihlajamaa, Aira Uusipaavalniemi (SN.); Surgical Hospital Dr. Anna-Maria Koivusalo (Inv.), Pasi Kyllönen (SN.); Turku University Hospital, Dr. Juha Perttilä, Dr. Erkki Kentala, Dr. Olli Arola, Dr. Outi Inkinen (Inv.), Jutta Kotamäki (SN.); Tampere University Hospital, Dr. Sari Karlsson, Dr. Jyrki Tenhunen (Inv.), Minna-Liisa Peltola, Sanna Mäkinen, Anna-Liina Korkala, Samuli Kortelainen (SN.); Kuopio University Hospital, Dr. Esko Ruokonen, Dr. Ilkka Parviainen (Inv.), Sari Rahikainen, Elina Halonen (SN.); Oulu University Hospital, Dr. Tero Ala-Kokko (Inv.), Sinikka Sälkiö, Tarja Lamberg (SN.).

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