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Survival of mechanically ventilated patients admitted to a specialised weaning centre

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Abstract *Objective:* Hospital mortality and survival rates of long-term ventilated patients. *Design:* Retrospective cohort study. *Setting:* Specialised national weaning centre. *Intervention:* Protocol-directed liberation from ventilator. *Patients:* Four hundred three of 640 patients with prolonged mechanical ventilation (MV) who were admitted to our respiratory intensive care unit (RICU) were studied. MV lasted longer than 2 weeks and patients had failed more than two weaning trials in the referring ICUs. The majority of patients (59.3%) had chronic obstructive pulmonary disease (COPD). *Results:* After a mean duration of 41 days of MV prior to transfer, 68% of patients were liberated from the ventilator. In total, 98 of 403 patients (24.3%) died during the stay in our hospital, 305 patients (75.7%) were discharged. Compared to the non-survivors, the survivors were characterised by younger age, longer length of stay in our RICU, lower severity of illness scores at admission, fewer cardiac illnesses and a higher rate of weaning success. In 31.5% of the discharged patients non-invasive MV (NIV) was initiated during the stay at our unit. We gathered follow-up data on 293 patients (96.1%). Post-discharge survival rates were 67.6% at 3 months, 49.4% at 1 year and 38.1% at 3 years. Length of survival was significantly dependent on age, weaning success and main diagnosis (i.e., prognosis in COPD is worse compared to thoracic restriction, neuromuscular disease and others) in the multivariate analysis. *Conclusions:* Difficult-to-wean patients have a high hospital mortality rate and poor long-term prognosis. Age, main diagnosis, severity of illness, weaning success and institution of NIV predict survival.

Keywords Difficult weaning from respirator · Outcome · Survival · Mortality

Introduction

Weaning failure has been defined as the permanent need of ventilatory support, total or partial, via endotracheal tube or mask [1]. Associated with the growing number of ventilated patients, the number of long-term ventilator-dependent patients is increasing. About 3–6% of patients admitted to adult intensive care units (ICUs) need prolonged mechanical ventilation (MV) [2, 3, 4]. Patients ventilated for a prolonged period often suffer from advanced chronic respiratory failure and have a substantial co-morbidity [5, 6, 7]. Furthermore these patients consume a high amount of intensive care resources [8]. During the last decade specialised weaning centres have been developed, especially in the United States, to improve medical care and outcome of ventilator-dependent patients and reduce costs [9, 10].

The aim of this study was to examine the hospital mortality and long-term survival rates of difficult-to-wean patients being ventilated for more than 14 days in

acute care hospital ICUs who were transferred to our respiratory ICU (RICU) to be weaned. As a secondary end point, we identify factors influencing hospital mortality and long-term survival rates in these patients.

Methods and patients

The hospital Krankenhaus Kloster Grafschaft (KKG) functions as a national weaning centre in Germany. We have over 10 years' experience in weaning a heterogeneous population of long-term ventilated patients. Our programme utilises the collaborative efforts of physicians, nurses and respiratory therapists. The responsible members of the medical and paramedical staffs and the essential technical equipment were constant throughout the observation period. According to the inclusion criteria, patients admitted between 01.01.1990 and 31.12.1999 were included in this study. Follow-up was performed from 01.07.1999 to 30.04.2000.

Pre-transfer procedure

Physicians of external ICUs who intended to transfer a difficult-to-wean patient to our institution initially contacted us via telephone, fax or e-mail. A standardised questionnaire dealing with the history of illness, weaning strategy, the number of unsuccessful weaning attempts and physiological data concerning the patient's status was administered to the external physician in charge of the patient. On average, patients were transferred to our institution 5–7 days after our initial contact with the referring hospital.

Admission criteria to respiratory intensive care unit, inclusion and exclusion criteria for the study

The following admission criteria to our RICU did not change over the 10-year observation period: difficult weaning from respirator due to dominant chronic respiratory failure, haemodynamic and renal stability. Vice versa the admission to our institution was refused in patients with multiple organ failure, haemodynamic instability, end-stage renal failure requiring haemodialysis or the need for surgical care. There were no other principal restrictions on admission to our hospital. Admission decisions were not strictly based on diagnosis, route of MV, prognosis, weaning or rehabilitation potential.

Patients with respiratory failure admitted to the RICU were included in this study if MV had lasted longer than 2 weeks in the referring ICU and they had failed at least two weaning attempts prior to transfer. The following patients were excluded from this study:

1. Patients who were successfully weaned within 24 h after admission to our RICU.
2. Prolonged ventilated patients who were deemed unlikely to be weaned (i.e. terminal state of rapid progressive neuromuscular diseases and of malignancy).
3. Patients who were transferred from our RICU to another specialised unit (for instance, for sepsis and multi-organ failure or for surgery) and were not readmitted to us.

Clinical and outcome data

The data collection included patient identification and demographic information; aetiology of ventilator dependency; dates of admission; weaning and discharge; length of stay; vital status; general health condition on admission and ventilator support status at discharge. This information was gathered from a central computer database.

Measurements and weaning protocol

In all patients, blood gas analysis during spontaneous breathing and while ventilated were carried out on the day of admission. Acute Physiologic and Chronic Health Evaluation (APACHE II) [11] was assessed within 24 h after admission. Body weight and height were measured to calculate the body mass index (BMI). Whenever possible, the following parameters were measured on the day of admission and discharge: spirometry, breathing pattern and inspiratory mouth pressures. The spirometry was done with a portable device (Vicatest, Hellige, Freiburg, Germany). Normal values for standard lung function data were taken from Quanjer et al. [12]. Tidal volume (Vt) and breathing frequency (fb) were measured with a portable pneumotachygraph (CP100, Bicore, Medilab, Estenfeld, Germany). Samples for capillary blood gas analysis (Gas Check, AVL, Bad Homburg, Germany) were obtained from the hyperaemic ear lobe. The blood gas analysis was performed while the patients were temporarily (3–5 min) disconnected from the ventilator, breathing room air without oxygen supplementation. During the disconnection all patients were continuously monitored with pulse oximetry and electrocardiogram, and a physician was always in attendance. Consistent with previous reports [13], none of the patients experienced a life-threatening response (i.e. arrhythmia or loss of consciousness) to this procedure. Mouth occlusion pressure (P0.1) was determined 0.1 s after the onset of inspiration. Maximal inspiratory pressure (P_{imax}) was measured by the method described by Black and Hyatt [14]. P_{imax} was taken as the highest value of five measurements. We sought to make measurements from residual volume.

The RICU of Krankenhaus Kloster Grafschaft is a 7-bed area associated with both a 4-bed respiratory intermediate care unit and a 15-bed unit specialised on home mechanical ventilation. Each day, the weaning team visited every weaning patient. The weaning team consisted of the specially trained pulmonary physician, the physician in charge and the nursing staff. All patients who received MV were treated by nurses with a 1:2 or 1:3 ratio. The nursing staff was specially trained in using an in-service programme addressing the needs of the particular patients. The admitting pulmonologist classified the main diagnosis and the initial reason for ventilator dependence (see Table 1). During the study, the responsible attendant (B.S.) and nurses, but also the methods of the weaning protocol, were identical.

All patients received a protocol-directed weaning strategy using intermittent T-piece trials. Based on clinical assessment [15] and according to clinical decision, the duration of spontaneous breathing was increased incrementally each day with a maximal duration used as intermittent period of 18 h. All patients received MV with volume- or pressure-targeted ventilators, depending on the patient's tolerance in the controlled, assist control or assisted mode [13, 16]. In patients who were successfully weaned after 24 h of spontaneous breathing, non-invasive mechanical ventilation (NIV) was initiated if a significant hypercapnia was found (in COPD: PCO_2>50 mmHg, in thoracic restriction or neuromuscular diseases: PCO_2>45 mmHg). Before starting NIV, the tracheostomy was closed with a button. Further details with respect to the adaptation to NIV have been described elsewhere [17]. If NIV was tolerated it was continued also after discharge from hospital as home mechanical ventilation.

Classifications and definitions

The initial cause of respiratory failure leading to ventilator dependence was classified into four categories as follows: acute respiratory failure (ARF) (i.e., acute respiratory distress syndrome, resus-

Table 1 Characteristics of patient collective

	n	Median (quartiles)
Age (years)	403	66.0 (58.2–71.6)
Body mass index (kg/m^2)	275	23.1 (19.6–27.6)
Duration of mechanical ventilation prior to transfer (days)	400	32.5 (19.0–50.0)
Tracheotomy after initial ventilation (days)	306	13.0 (7.0–19.0)
Length of ICU stay in our hospital (days)	403	14.0 (8.0–20.0)
Duration of weaning (days)	268	6.0 (3.0–9.0)
	n	%
Gender		
male	260	64.5
female	143	35.5
Main diagnosis		
COPD	239	59.3
Thoracic restriction	55	13.6
Neuromuscular disease	42	10.4
Cardiac decompensation	16	4.0
Central breathing disorder	9	2.2
Obesity hypoventilation syndrome	23	5.7
Others	19	4.7
Initial cause of mechanical ventilation		
Acute respiratory failure	50	12.5
Acute respiratory failure on chronic basis	271	67.6
Post surgery	42	10.5
Others	38	9.5
Modes of mechanical ventilation on admission		
Controlled (volume or pressure targeted)	19	5.1
Assisted	178	48.1
Controlled + assisted	173	46.8
Route on admission		
Endotracheal tube (nasal or oral)	103	26.3
Tracheotomy	288	73.7
Admission source		
Medical ICU	266	67.3
Anaesthesiological ICU	88	22.3
Interdisciplinary ICU	24	6.1
Surgical ICU	17	4.3

citation, pneumothorax, pulmonary embolism), acute exacerbations of chronic respiratory diseases (i.e., COPD, neuromuscular disease or thoracic restriction), postoperative respiratory failure and others. The main diagnoses of underlying chronic diseases were classified into seven categories: COPD, thoracic restriction (i.e., scoliosis, post tuberculosis syndrome), neuromuscular disease, cardiac failure, central breathing disorder, obesity hypoventilation syndrome and others.

Weaning success was defined as survival for at least 7 continuous days and nights without invasive MV. The initiation of NIV did not negate weaning success. During the observation period of 7 days of spontaneous breathing after weaning from the respirator, patients were differentiated into weaning success with "clinical stability" or "clinical instability". Weaning success with clinical stability was characterised by: (1) absence of hyperthermia (temperature <38°C), (2) stable haemodynamics (heart rate <120/min, mean arterial blood pressure >100 mmHg) and blood gases (SaO_2 with supplemental O_2>90%, PCO_2<60 mmHg, pH >7.35 during spontaneous breathing), (3) conscious and cooperative patient, (4) effective cough (judged by the respiratory therapist) and no indication for fibre optic bronchoscopy to remove secretion. Patients who did not fulfil these criteria were defined as weaning success with clinical instability. They were not reconnected to the ventilator (even if tracheotomy was still in place).

Patients who did not demonstrate clinical improvement and were still dependent on invasive MV after 14 days on our weaning protocol, were defined as weaning failures. Death during MV was defined as weaning failure as well.

Follow-up after discharge

Information was obtained by telephone interview. The survivors and/or their relatives were contacted by one of the investigators (S.E.). All contacts were made from 01.07.1999 to 30.04.2000 to ensure that the follow-up included all patients. Information was obtained to determine whether and where the patient was living or, if deceased, the date and cause of death were obtained. Use of institutional, community and family resources (and subsequent hospitalisations) were recorded. Any admissions to extended care fa-

cilities were documented as well. When patients or family members were not available, the patient's general physician or residences' registration office were contacted and asked for the same information. Survival after discharge was computed in days.

Statistics

The results are expressed as median and quartiles. In all cases a two-tailed *p* value less than 0.05 was considered to be significant. All data were analysed using Statistica 5.5 software [18].

Hospital mortality

The data pool was divided into survivors (i.e., discharged from hospital) and non-survivors (i.e., death in hospital). The following parameters were compared between these two groups: age, BMI, main diagnosis, cause of intubation, length of MV in external ICU, PCO_2, PO_2, breathing pattern (fb, Vt), P0.1 on admission, APACHE II within 24 h after admission to the RICU, weaning success and length of stay in the RICU. In a case of interval scaled parameters the comparison was performed using *t*-tests for independent samples or ANOVA if assumption of normal distribution was met; Mann-Whitney U-tests or Kruskal-Wallis ANOVA was used otherwise. For comparison of nominal parameters, configuration frequency analysis (CFA) based on chi-square statistics was used [19]. To detect different hospital mortality rates between study years χ^2 test for trend according to Schlesselman [20] was calculated.

Long-term survival

The following parameters were tested regarding influence on survival rate of patients discharged from hospital: age, BMI, main diagnosis, cause of respiratory failure, length of MV at external ICU, APACHE II within 24 h after admission to our ICU, weaning success, lung function, PO_2, PCO_2, Vt, fb/Vt (rapid shallow breathing index) and P_{imax} at discharge, and additional treatment (NIV and O_2) at discharge. The survival analysis was performed with Kaplan-Meier product limit method. Nominal parameters were tested univariate using Gehan's generalised Wilcoxon test. In cases of parameters on interval scale, Cox's proportional hazard regression was used for univariate analysis. A multivariate model, also using Cox's regression, was constructed including all (recoded) nominal and continuous parameters with less than 15% missing values. If necessary, parameters were transformed into gaussian distribution before analysis.

Results

Patients excluded from the study

During the observation period 640 patients with prolonged MV were admitted to our institution. According to exclusion criteria, 237 patients (75 female, 162 male) were excluded. Reasons for exclusion were successful weaning within 24 h after admission to the RICU (56), terminal illnesses (126) and transfer from our unit to a specialised unit for an emergency (e.g., surgery or neuropsychiatric, 27) or multi-organ failure (28). We did not

Table 2 Differences between hospital survivors and non-survivors

	Survivors *n*=305	Non-survivors *n*=98	*n*	*p*
	Median (quartiles)			
Age (years)	64.7 (58.0–70.4)	69.7 (59.2–74.1)	403	0.0003
Length of stay at our ICU (days)	14.0 (9.0–20.0)	10.0 (7.0–16.0)	403	0.0001
APACHE II score	15.0 (13.0–18.0)	17.0 (15.0–22.0)	359	0.0001
P0.1 (cmH_2O)	3.5 (2.4–4.8)	4.5 (2.7–5.8)	230	0.014
	n	*n*	% Hospital mortality	
Main diagnosis				
COPD	181	58	24.3	
Thoracic restriction	45	10	18.2	
Neuromuscular disease	33	9	21.4	
Cardiac decompensation	7	9	56.3*	
Central breathing disorder	5	4	44.4	
Obesity hypoventilation syndrome	21	2	8.7	
Others	13	6	31.6	
Weaning outcome				
Not weanable	58	70	54.7*	
Weaned, but unstable	31	22	41.5	
Weaned and stable	216	6	2.7*	

Percentage of patients who died in hospital is calculated for every subgroup in the right column
*Marks a significant deviation of subgroup from total mean (CFA)
(*APACHE* Acute Physiologic and Chronic Health Evaluation, *P0.1* mouth occlusion pressure 0.1 s after start of inspiration, *COPD* chronic obstructive pulmonary disease)

Table 3 Parameters influencing long-term survival (univariate analysis)

Relative risk is calculated as exp(β) per 1 unit change (*APACHE* Acute Physiologic and Chronic Health Evaluation, *FEV1%VC* forced expiratory volume in 1 s in percent of vital capacity, P_{imax} maximal inspiratory mouth occlusion pressure, *Vt* tidal volume. Rapid shallow breathing index: *Fb/Vt* breathing frequency/tidal volume, T_i/T_{tot} ratio of inspiration/total breathing cycle, *VE* minute ventilation)

Parameter	*n*	*p*	Relative risk (95% CI)
Age (years)	293	0.0001	1.037 (1.021–1.053)
Days of mechanical ventilation prior to transfer	289	0.010	1.004 (1.001–1.007)
APACHE II	262	0.0037	1.061 (1.021–1.102)
PO_2 (mmHg) (spontaneous breathing)	185	0.0001	0.968 (0.954–0.983)
PCO_2 (mmHg) (spontaneous breathing)	185	0.0001	1.054 (1.027–1.080)
FEV1%VC	121	0.034	0.983 (0.968–0.999)
P_{imax} (cmH_2O)	156	0.016	0.984 (0.971–0.997)
Vt (ml)	174	0.0003	0.998 (0.996–0.999)
Fb/Vt (breaths/min per ml)	174	0.0025	1.005 (1.002–1.009)
T_i/T_{tot}	172	0.031	0.965 (0.934–0.997)
VE (l)	174	0.0019	0.895 (0.834–0.960)
Main diagnosis	293	0.0013	
"Weanability"	293	0.0001	
Non-invasive mechanical ventilation	282	0.0001	

follow up the latter group of patients because they were not readmitted into our unit.

Patients characteristics

In total, 403 patients were included. Anthropometric data, diagnosis, details concerning MV (e.g., cause of intubation, admission source, duration of MV in external ICU) are given in Table 1.

In-hospital mortality

Ninety-eight (24.3%) of 403 patients died during the stay in our hospital (group I). Three hundred five (75.7%) patients were discharged (group II). We found no significant differences (χ^2=0.04; p=0.83) in in-hospital mortality among the years of admission (1990–1999). Severity of underlying diseases and acute status (i.e. APACHE II) of the patient population were also constant throughout the observation period. Differences between survivors and non-survivors are shown in Table 2. Compared to the non-survivors, the survivors were characterised by younger age, longer length of stay in the RICU, lower APACHE II scores and lower P0.1. Furthermore, survivors had fewer cardiac illnesses and were more likely to have weaning success with clinical stability. There was no difference between the groups concerning BMI, reason for initial ventilation, length of MV prior to transfer, blood gases and breathing pattern on admission to the RICU. Patients older than 80 years showed an in-hospital mortality of 50%.

Non-invasive ventilation

After the initial 24-h spontaneous breathing trial, 114 patients remained hypercapnic. In all of them a NIV trial was performed. Ninety-six (31.5%) of the discharged patients continued to use NIV intermittently at night: 39 COPD patients, 23 with thoracic restriction, 20 with neuromuscular diseases and 14 with other causes. The NIV subgroup was younger (55.8 vs 65.3 years; p<0.001), was on MV for a shorter time (36.4 vs 47.1 days; p<0.02) and in better condition at time of admission (APACHE II score: 13.5 vs 16.2; p<0.001) compared to all the other discharged patients not receiving NIV. NIV was not tolerated by a subgroup of 18 patients. These patients were characterised by high age (69.2±7.1 years) and high APACHE II score on admission (18.5±5.4). Most of them were COPD patients (16 of 18).

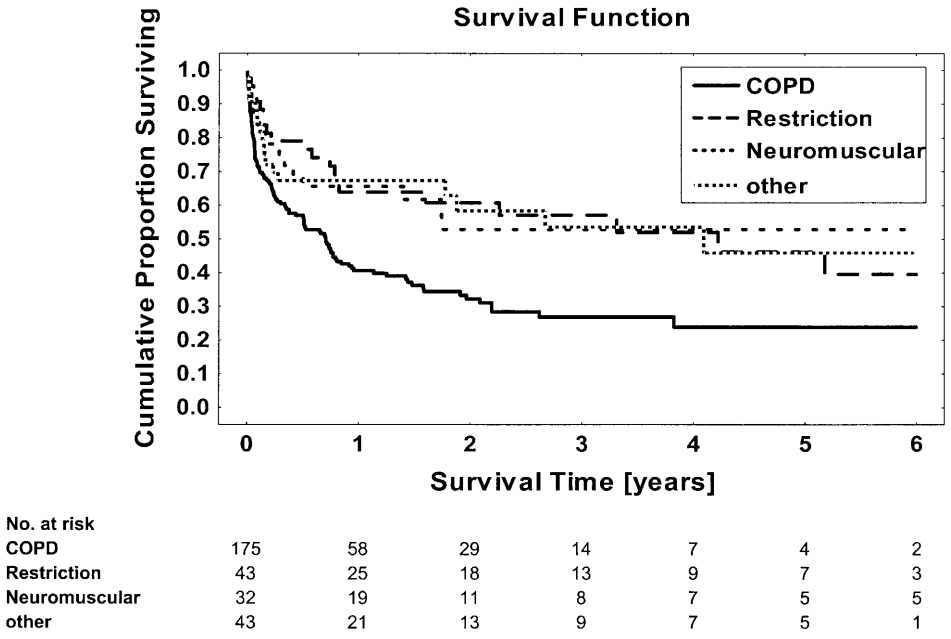
Discharge status

Among the 305 patients who survived to discharge from our hospital, 165 patients (55.0%) were transferred back to their referring hospitals, while 24 (8.0%) were transferred to different external hospitals or nursing facilities. Eighty-six patients (28.2%) were discharged to their private homes and 25 patients (8.3%) were transferred to rehabilitation facilities.

Long-term survival

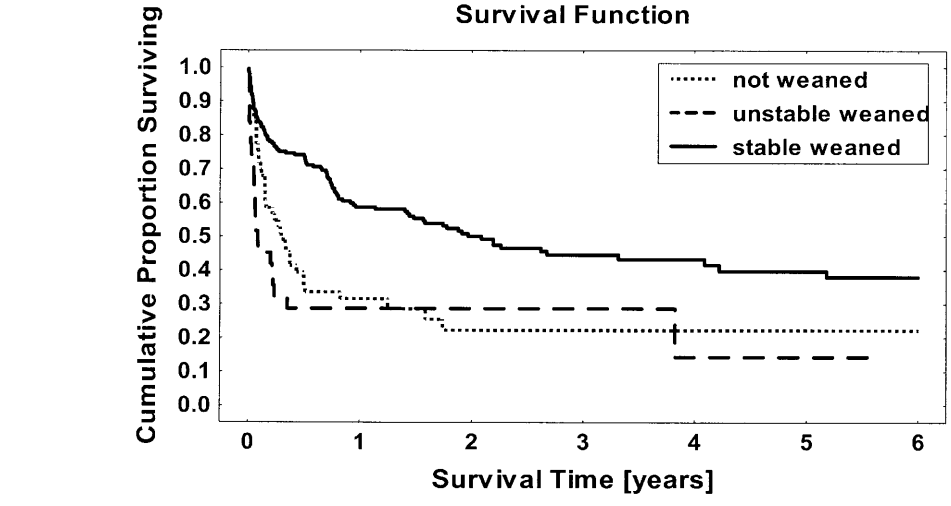
Long-term survival data were available from 293 of the 305 patients discharged (96.1%); survival was analysed in only these patients. At the end of the observation period (30th April, 2000) 124 patients (42.32%, group IIA) of 293 were still alive and 169 patients (57.68%, group IIB) were dead. The mortality rate after discharge was 32.4% at 3 months, 50.6% at 1 year, 61.9% at 3 years and 66.6% after 5 years.

In univariate analysis, length of survival was significantly dependent on the following parameters (Table 3): age, length of MV at external ICU, APACHE II, main diagnosis, weaning success, blood gases at discharge, NIV, forced expiratory volume at 1 s in percent of vital capacity (FEV1%VC) at discharge, breathing pattern and max-



No. at risk							
COPD	175	58	29	14	7	4	2
Restriction	43	25	18	13	9	7	3
Neuromuscular	32	19	11	8	7	5	5
other	43	21	13	9	7	5	1

Fig. 1 Kaplan-Meier survival curves according to diagnostic categories. Main diagnosis had a significant effect on post-discharge survival of patients (n=293; p<0.0013)



No. at risk							
not weaned	53	14	4	3	3	2	2
unstable weaned	31	6	4	2	1	1	
stable weaned	209	103	63	39	26	18	9

Fig. 2 Kaplan-Meier survival curves according to "weanability". Weaning success in a state of clinical stability significantly improves post-discharge survival of patients (n=293; p<0.0001)

imal inspiratory mouth occlusion pressure (P_{imax}). Parameters with the highest significance were younger age, weaning success and improved blood gases (i.e., increased PO_2 and decreased PCO_2). Additionally, patients receiving NIV or NIV plus O_2 had a better prognosis than patients without NIV or with only additional O_2 treatment (p<0.0001).

Figure 1 shows the Kaplan-Meier survival curves of 293 patients according to the main diagnoses. Compared to thoracic restriction and neuromuscular disease, COPD showed the highest mortality (p<0.0013) despite comparable APACHE II scores on admission (16.2 vs 16.1). Survival curves depending on weaning outcome are given in Fig. 2. Compared to successfully weaned stable patients, patients who failed weaning and patients who were weaned but remained clinically unstable showed a significantly higher mortality (p<0.0001). In univariate analysis, the length of survival was not influenced by BMI, cause of intubation, duration until successful weaning, P0.1 or lung function data, except for FEV1%VC.

According to the multiple regression analysis age, main diagnosis and weaning outcome were independent

Table 4 Multivariate model for prediction of long-term survival

	p	Relative risk (95% CI)
Age (years)	0.0057	1.024 (1.007–1.042)
Days of MV prior to transfer	0.3260	1.002 (0.998–1.006)
APACHE II	0.3787	1.019 (0.977–1.064)
Main diagnosis		
COPD	Reference	1.00
Thoracic restriction	0.0181	0.542 (0.327–0.901)
Neuromuscular disease	0.0111	0.444 (0.237–0.831)
Others	0.0095	0.496 (0.292–0.843)
Weaning outcome		
Weaned and stable	Reference	1.00
Weaned, but unstable	0.0010	2.261 (1.391–3.675)
Not weanable	0.0001	2.355 (1.564–3.547)

Only parameters with less than 15% missing values are included (n=262; p 0.0163) (*APACHE* Acute Physiologic and Chronic Health Evaluation, *MV* mechanical ventilation, *COPD* chronic obstructive pulmonary disease)

variables influencing long-term survival (n=262; p=0.0163; Table 4). In terms of diagnosis, this means that the survival rate of patients with thoracic restriction, neuromuscular diseases and other diagnoses was higher compared to COPD patients and, regarding weaning outcome, that the prognosis of clinically stable patients who were weaned from ventilator was better than that of patients with weaning failure or clinical instability. NIV was not included in this analysis because it was not randomly applied.

Discussion

In our heterogeneous population of patients with prolonged MV we found a hospital mortality rate of 24%, the overall 1-year survival rate was 37% and the overall 2-year survival rate was 32%. Hospital mortality was associated with higher age, severity of illness (APACHE II), and respiratory drive (i.e., P0.1), weaning failure and clinical instability after formal weaning success.

About 60% of our patients suffered from severe COPD. The poor prognosis of ventilator-dependent patients with chronic lung diseases has also been reported in other studies: A 1-year mortality rate in COPD patients after acute respiratory failure of 54% was reported by Jessen et al. [21]. Furthermore Menzies et al. [22] showed a 1-year survival rate of 34% in 55 COPD patients ventilated for more than 14 days. Kaelin et al. [23] confirmed this in another COPD population. Nava et al. [13] studied survival rate and weaning outcome in 42 tracheotomised COPD patients requiring MV for longer than 21 days; the 2-year survival rate was 40%.

A unique characteristic of this study is the different outcome of the heterogeneous sub-populations. Compared to COPD patients, the prognosis of patients with neuromuscular diseases and thoracic restriction was markedly better. Such comparisons of underlying diagnoses has rarely been performed on ventilator-dependent patients. However, our findings are similar to studies from the early 1990s, which focused on the outcome of different patient groups requiring home mechanical ventilation [24, 25]. In these studies, patients with COPD who required NIV also had the poorest prognosis.

About one-third of the patients who were discharged began NIV for chronic hypercapnic respiratory failure. The long-term use of NIV in these patients is still controversial. However, more severe hypercapnic patients are likely to benefit from this form of ventilatory support [26, 27]. Based on clinical parameters (see “Classifications and definitions”) after spontaneous breathing longer than 7 days, we divided weaning success patients into stable and unstable subgroups. Patients who were successfully weaned but remained clinically unstable had outcomes comparable to weaning failure patients. Therefore, categories of “weaning success” or “weaning failure” might be misleading and are probably not adequate to predict outcome.

We found age to be associated with increased mortality. Accordingly, both Swinburne et al. [28] and Cohen et al. [29] suggest that the outcome of ventilator-dependent patients older than 80 years is extremely poor. In the series of Swinburne the mortality was 91% in patients who required MV for more than 15 days. Similarly, in the population of Cohen a mortality rate of 78% was found if patients were mechanically ventilated longer than 3 days.

We excluded patients from the study who had no chance to be weaned or were in the terminal stage of their illnesses (see “Exclusion criteria”). Including this population in the study, the prognosis of the whole population would be even worse. However, we also excluded patients who were successfully weaned within 24 h after admission to our RICU from the analyses in this study. These patients were not truly ventilator-dependent. However, in most of these cases the essential requirements and logistic to stabilise the patients’ spontaneous breathing immediately after extubation could not be achieved in the referring ICUs.

This study focuses on the hospital and long-term survival of difficult-to-wean patients. Therefore weaning outcome – expressed as success or failure – was not a primary end point. Accordingly, we did not aim to evaluate parameters or indices predicting weaning success in this investigation.

Limitations

The main weakness of this study is its retrospective, non-controlled design in a single unit. This study does not investigate the impact of the weaning strategy applied. However, the study deals with short- and long-

term survival rates of ventilator-dependent patients, due to chronic illness, treated in a weaning centre. The results of this study are probably not influenced by the different severities of illness of the patients admitted, since this factor did not change during the decade analysed. Furthermore the essential issues of the weaning protocol, technical equipment, measurements performed and the main, responsible personnel of the weaning team were constant during the whole observation period.

This investigation describes the outcome of a single weaning centre. Our findings may not be applicable to other centres, nor is a general application of the underlying weaning protocol possible. However, the literature has consistently shown that about 50% of so-called "unweanable" patients can, in fact, be weaned in a specialised RICU [2, 9, 10, 13, 22, 30, 31, 32, 33].

We conclude that difficult-to-wean patients have high hospital, 1- and 3-year mortality rates. Age, main diagnosis, severity of illness, "weanability" and NIV influence the survival rate. Multi-centre studies with a common protocol are needed to compensate for the shortcomings associated with a single centre study.

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