



Respiratory failure in elderly patients

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As the US population ages more patients will develop respiratory failure requiring mechanical ventilation. The 1990 US census estimated that persons aged older than 65 years comprised 13% of the total population of the United States. By the year 2030 the number of adults aged 85 or older is expected to double. It has been estimated that 21% of the US population will be older than 65 by the year 2020. In addition, general improvements in medical care have allowed patients to survive diseases that otherwise would have resulted in death. Thus, it is not surprising that an increasing proportion of patients admitted to the medical (MICU) and surgical intensive care units (SICU) are older than 65 years, and this trend is likely to accelerate. Because respiratory failure is the most common cause of MICU admission, it is also not surprising that the number of elderly patients requiring mechanical ventilation is also increasing. The high prevalence of serious respiratory diseases with increasing age (eg, chronic obstructive pulmonary disease [COPD] and pneumonia) together with the evolving expectations about care on the part of patients and their families present challenges for both care of the individual patient and for the future allocation of health system resources.

This article examines selected, clinically important aspects of respiratory failure and its management in elderly individuals, including some of the factors that make older patients more likely to develop respiratory failure, approaches to implementation of and liberation from mechanical ventilation, and the costs of this care. Finally, the article considers the rising incidence of chronic respiratory failure and its implications for long-term mechanical ventilation in carefully selected elderly patients. Although it appears as though older patients are increasingly likely to develop respiratory failure requiring mechanical ventilation there is no clear evidence that elderly patients are uniformly at increased risk of failing to wean from the ventilator. Numerous uncertainties relating to respiratory

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failure in this population must be addressed through future prospective study in an effort to enhance patient care.

Age-related predisposition to respiratory failure in elderly patients

Many interacting factors lead to age-related alterations of respiratory function. From the age of 30, patients experience a decrease in their forced expiratory volume in 1 second (FEV_1) of between 10 to 30 mL per year [1]. This age-related decline in FEV_1 is accelerated in persons who are active cigarette smokers [1]. Further, there are age-related changes that increase lung and decrease chest wall compliance, with an overall reduction in compliance of the total respiratory system that increases the work of breathing [2]. Accentuated closure of dependent lung zones and associated increases in ventilation-perfusion mismatching lead to a widened alveolar-arterial oxygen gradient, with a direct relationship between aging and a decrease in the partial pressure of arterial oxygen (PaO_2) [2]. Carbon monoxide-diffusing capacity also declines after the age of 40 [3]. Reduced effectiveness of cough and compromised mucociliary clearance with age alter local defenses predisposing patients to pneumonia. Further, the reduced responsiveness of respiratory centers to hypoxemia and hypercarbia are important changes in the central controls of respiration, making older persons especially vulnerable to the effects of sedation.

With normal aging, individuals progressively lose nonfat body mass and have increased fat stores. This decline in muscle function may cause a reduction in strength, including that of the diaphragm and accessory respiratory muscles, and predispose individuals to fatigue when the work of breathing is increased by disease. Moreover, older persons who are inactive lose more muscle mass compared with active patients of similar age [4]. Profound effects of deconditioning may compromise cardiopulmonary reserve substantially, and an otherwise tolerable infection or acute insult that increases metabolic demands may precipitate respiratory failure. In addition, older patients may develop osteoporosis, especially those who have smoked or have used glucocorticoids for long periods of time. These patients are at risk for the development of compression fractures, which may lead to discomfort and splinting (with a resultant restrictive ventilatory defect, atelectasis, and compromised cough), and place the patients at increased risk of respiratory infections.

An important but underemphasized factor in the development of respiratory failure in older patients relates to improved medical technologies that have resulted in survival from previously fatal illnesses. For example, progress in the treatment of myocardial infarction, congestive heart failure, renal failure, and cancer have led to increased patient survival. These surviving patients, however, often have compromised pulmonary reserve. In addition, these patients are at increased risk for developing infections especially those involving the lung, urinary tract, and bloodstream [5]. All of these infections may increase a patient's metabolic demands which in the presence of limited cardiopulmonary reserve

may indirectly lead to the development of respiratory failure. Alternately, sepsis may, through the effects of primed neutrophils and other humeral mediators of host defenses, lead to direct injury of the alveolar-capillary membrane with development of acute respiratory distress syndrome (ARDS) [6]. In patients who present with trauma as their primary risk factor, Hudson et al [7] observed that older age (> 70 years compared with 18–29 years) and female gender were associated independently with an increased risk for ARDS (relative risks 2.3 and 1.63, respectively).

Another important contributory cause of the increasing incidence of respiratory failure in elderly patients relates to improved survival from neurologic disorders including cerebrovascular accidents. These patients are often at increased risk for developing aspiration which is a frequent precipitant of respiratory failure [6,8]. Major factors that predispose elderly patients toward developing respiratory failure are shown in Fig. 1. Some of these factors are potentially reversible through improved nutritional status, exercise, smoking cessation, and the use of immunizations (eg, influenza and pneumococcal vaccines). Careful consideration of these and other potentially modifiable factors may help to decrease the risk of developing respiratory failure in this patient population.

Common causes of respiratory failure in elderly patients

Superimposed on normal changes in respiratory function with aging are the effects of myriad pulmonary and nonpulmonary disorders. Although many

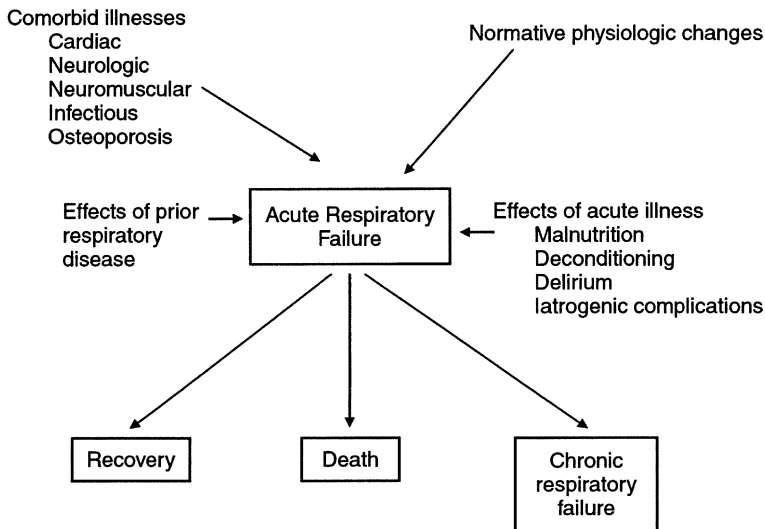


Fig. 1. The complex interacting factors that contribute to the development of and recovery from acute respiratory failure in elderly patients.

patients at risk for development of respiratory failure have primary pulmonary diseases (eg, COPD, interstitial lung disease, and pneumonia), cardiac, neurologic, metabolic, and nutritional disorders may all predispose patients to the development of respiratory failure. Thus, the development of respiratory failure in elderly individuals can be classified generally as originating from either pulmonary or nonpulmonary causes. The relative mix of primary indications for mechanical ventilation varies considerably among institutions according to patient populations and often-unstated differences in the process of care. In one representative prospective study of 300 mechanically ventilated patients (including 63 individuals older than 75 years) in medical and coronary ICUs, approximately 50% of the patients had primary respiratory diagnoses [9] (Table 1). Pneumonia, emphysema, and ARDS were the most common causes, whereas cardiovascular diseases accounted for another 25%. Another investigation of respiratory failure in persons older than 80 years reported that cardiac causes including cardiopulmonary arrest were the most common causes of respiratory failure with pulmonary disorders (including COPD, ARDS, and pneumonia) representing the second most likely causes of respiratory failure. Because many patients who presented with nonpulmonary diagnoses also had underlying lung disease, it is likely that their compromised pulmonary function placed them at increased risk for the development of respiratory failure.

Seneff et al [10] studied 166 older persons (mean age, 68 years) with COPD who required mechanical ventilation. In this group of patients COPD exacerbation was an infrequent cause of either ICU admission or respiratory failure, whereas pneumonia, ARDS, congestive heart failure, sepsis, and encephalopathy were the most common causes of respiratory failure. Although the underlying lung disease may have contributed to the development of respiratory failure, it was not, in most instances, its proximate cause. In a different study these investigators evaluated the Acute Physiology and Chronic Health Evaluation III (APACHE III) database of 17,440 ICU admissions [11]. In this population, the duration of intubation for patients who developed respiratory failure was related

Table 1
Distribution of diagnoses among 300 mechanically ventilated patients^a

Primary diagnosis	Patients	
	<i>n</i>	%
Cardiac	81	27
Pulmonary	146	49
Gastrointestinal	20	7
Cancer	16	5
Neurologic	16	5
Toxic-metabolic	16	5
Renal	5	2
Total	300	100

Adapted from Ely EW, Evans GW, Haponik EF. Mechanical ventilation in a cohort of elderly patients admitted to an intensive care unit. *Ann Intern Med* 1999;131:96–104.

^a Diagnoses were evenly distributed among persons <75 years and those \geq 75 years ($P>0.2$).

primarily to the principal diagnosis rather than to the underlying lung disease. The presence of chronic lung disease, however, increased the risk of prolonged ventilation [11]. Of the 5915 patients who required mechanical ventilation on the first ICU day roughly 18% had a primary respiratory diagnosis and 15% were postoperative patients. Whereas combined severity of illness and nutritional status were predictive of total ventilator days, each by itself was not [11]. Persons aged 60 years and older did not have more ventilator days compared with younger individuals.

Based on these observations, experienced chest physicians have expressed varying views about the relative benefits and risks of mechanical ventilation, depending on the patient's age and clinical scenario (Table 2). Pulmonologists participating in a geriatric education retreat noted that for potentially short-term, relatively reversible causes, the benefits of mechanical ventilation in elderly patients were thought to outweigh the risks. Risks were thought to exceed benefits for longer durations of ventilation and with increasing patient age, particularly for ARDS or pneumonia (E. Haponik, unpublished observations, 1998). The relationships of such perspectives to intensivists' practice behaviors require further study.

In a community-based referral hospital setting, Suchyta et al [12] identified the age of 55 as a cut point associated with increased mortality (64% versus 45%) from ARDS. Significantly more older nonsurvivors had life support withdrawn (73% versus 50% in younger nonsurvivors) despite the presence of more severe disease in the younger nonsurvivors. This increased likelihood of withdrawal applied even in the absence of chronic disease states and suggests that age bias may influence decisions to withdraw support [12]. Thus, more information is needed regarding the process of care of elderly patients, including the roles of potential gender biases favoring less vigorous care of critically ill women with respiratory failure. These findings are consistent with comprehensive observations from the Study to Understand Prognoses and Preferences for Outcomes and Risks of Treatment (SUPPORT). These investigators demonstrated important

Table 2
Mechanical ventilation: pulmonologists' estimates of relative benefit/risk versus patient age

Clinical Scenario	Patient age, y		
	45	55	85
≤ 5 d for COPD exacerbation	7.9	2.3	1.0 *
≤ 5 d for pneumonia	7.9	3.4	2.0
>5 d for COPD exacerbation	8.0	3.4	1.8
>5 d for ARDS	5.5	1.7	0.8**
>5 d for pneumonia	2.0	1.5	0.6**
Tracheostomy for prolonged intubation	4.0	2.6	1.2**

Abbreviations: ARDS, acute respiratory distress syndrome; COPD, chronic obstructive pulmonary disease.

Data from Haponik E, Hazzard W. Unpublished observations, 1998.

* Change over age, $P < 0.017$.

** Change over age, $P < 0.001$.

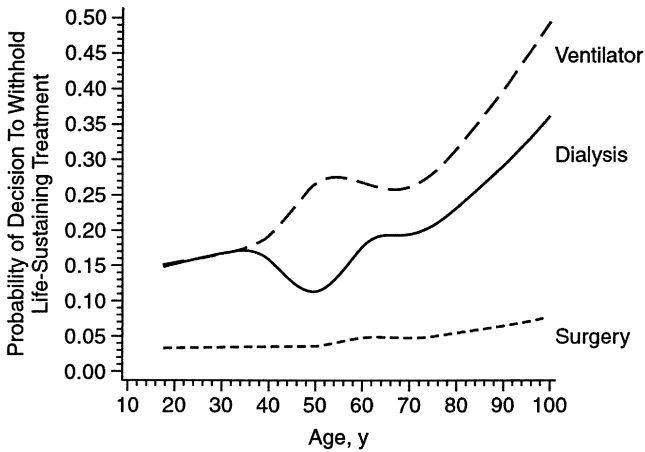


Fig. 2. Patient age influenced the adjusted probability of a decision to withhold each life-sustaining treatment by day 30. (From Hamel MB, Davis RB, Teno JM, et al. Older age, aggressiveness of care, and survival for seriously ill, hospitalized adults. SUPPORT investigators: Study to Understand Prognoses and Preferences for Outcomes and Risks of Treatments. *Ann Intern Med* 1999;130:116–25.)

relationships between patient age and clinicians' use of potential life-saving therapy including mechanical ventilation (Fig. 2). In this prospective cohort study of 9105 hospitalized persons, older patients were less often offered such interventions [13]. Neither the number of dependencies of activities of daily living nor the presence of dementia was associated independently with the decision to withhold mechanical ventilation [13].

Liberation from ventilatory support: effects of age on outcomes

Concerns about the potential hazards and appropriateness of mechanical ventilation of older persons and the feasibility of liberation from such support merit emphasis. Recent controlled clinical studies have shown that a respiratory therapist–driven weaning protocol is superior to a general bedside physician approach [14]. These investigations have provided useful insights about the effect of age-dependent outcomes of patients treated with mechanical ventilation after admission to an ICU and underscore the importance of timely recognition of recovery of respiratory function by means of carefully monitored spontaneous breathing trials. In a prospective cohort study, 63 patients aged 75 years or older and 237 patients younger than 75 years who required mechanical ventilation were evaluated [9]. The median duration of mechanical ventilation was 4.2 days for patients aged 75 years or older and 6.4 days for patients younger than 75 years ($P = 0.14$). In addition, the length of time required to successfully pass a daily spontaneous breathing screening test was shorter in patients older than 75 years (risk ratio, 1.58; 95% confidence interval [CI], 1.13–2.22; $P = 0.03$). The inpatient hospital mortality rate was 38.1% among patients older than 75 years

and 38.8% among younger patients ($P > 0.2$) [9]. Thus, age, by itself, did not seem to adversely affect the duration of mechanical ventilation or likelihood of success in weaning from the ventilator in patients with a wide spectrum of causes of respiratory failure. Detailed analysis of the course of recovery of patients with acute lung injury (ALI) and ARDS has shown that older persons attained certain important milestones of physiologic measurements (eg, passing daily screens and spontaneous breathing trials) at a pace similar to that in younger persons, suggesting that older patients had similar rates of recovery from respiratory failure compared with younger persons. The total duration of intubation, however, was longer in older persons (despite apparently acceptable physiologic measures), suggesting that important effects of other factors, and/or differences in the process of care accounted for the prolonged mechanical ventilation and MICU stays (Fig. 3). Common interacting factors included delirium, adverse effects of sedative and/or hypnotic agents, and other complications associated with deconditioning and frailty. Addressing these areas presents important opportunities for improving outcomes.

An overview of the literature showing age-specific data related to the use of mechanical ventilation is outlined in Table 3. Many of these previous investigations have not included adjustments for severity of illness and multivariable analysis. Zillerberg and Epstein [15] compared 76 patients aged 65 years or younger with 31 MICU patients older than 65 years who required mechanical ventilation. Using multivariate analysis to limit the effect of confounding variables, the authors noted older age to be an independent predictor of mortality ($P < 0.001$) [15]. It is likely that the contrasting findings among published investigations may parallel differences in patient population and referral patterns,

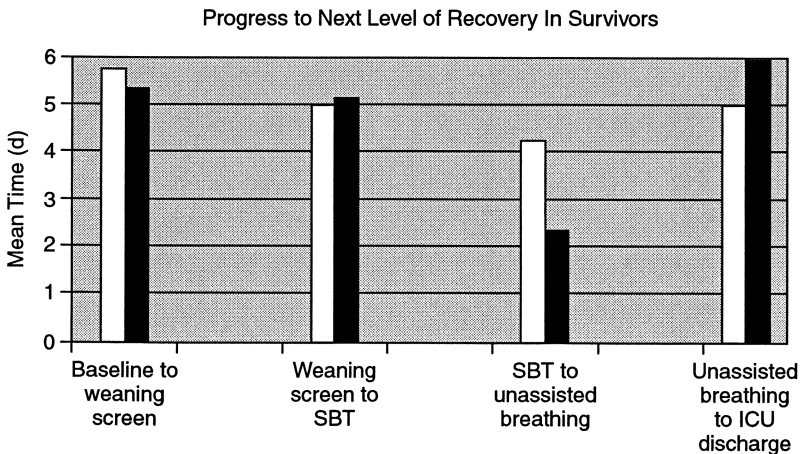


Fig. 3. Age-related progress toward recovery from respiratory failure. SBT, spontaneous breathing trials. (Adapted from Ely EW, Wheeler AP, Thompson BT, et al. Recovery rate and prognosis in older persons who develop acute lung injury and the acute respiratory distress syndrome. *Ann Intern Med* 2002;136:25–36.)

Table 3
Relationship of patient age to outcome of respiratory failure

Reference	No. patients	Age, y	Study design	Inclusion criteria	Mortality rate, %	Multivariate analysis	Severity adjustment	Influence age on outcome
Nunn et al, 1979 [41]	15	≥75	Prospective	ICU	73	No	No	Yes
Campion et al, 1989 [42]	565	≥75	Retrospective	ICU/CCU	16	No	No	No
Fedullo et al, 1983 [43]	84	≥70	Retrospective	MICU only	39	No	No	No
Witek et al, 1985 [44]	51	>70	Prospective	ICU	51	No	No	Yes
Mclean et al, 1985 [45]	49	≥75	Retrospective	ICU	43	No	No	No
Elpern et al, 1989 [46]	95	≥60	Retrospective	ICU ≥3 d	66	No	No	Yes
Tran et al, 1990 [47]	92	>70	Retrospective	MICU only	46	No	No	Yes
O'Donnell et al, 1991 [48]	17	≥70	Retrospective	ICU	59	No	No	No
Pesau et al, 1992 [49]	99	≥70	Retrospective	ICU	60	Yes	Yes	No
Gracey et al, 1992 [50]	496	>65	Retrospective	ICU	46	No	No	Yes
Chelluri et al, 1992 [51]	34	≥85	Retrospective	MICU only	38	No	No	No
Satuffer et al, 1993 [52]	118	≥70	Retrospective	ICU	62	Yes	No	Yes
Swinburne et al, 1993 [24]	282	≥70	Retrospective	ICU	69	No	No	No
Cohen et al, 1993 [27]	109	≥80	Retrospective	ICU ≥3 d	62	No	No	Yes
Papadakis et al, 1993 [53]	138	≥70	Retrospective	ICU	76	Yes	Yes	Yes
Dardaine et al, 1995 [54]	110	≥70	Retrospective	ICU	38	No	No	No
Cohen et al, 1995 [55]	21,342	≥80	Retrospective	ICU	59	No	No	Yes
Steiner et al, 1997 [56]	40	>65	Prospective	ICU/Stroke	32	Yes	No	Yes
Kurek et al, 1997 [57]	3256	≥70	Retrospective	Tracheostomy	64	No	No	Yes
Zillerberg et al, 1998 [16]	31	≥65	Prospective	MICU	74	Yes	Yes	Yes
Kurek et al, 1998 [58]	4101	≥70	Retrospective	ICU	55	No	No	Yes
Ely et al, 1999 [9]	63	≥75	Prospective	MICU/CCU	39	Yes	Yes	No
Luhr et al, 2000 [18]	277	≥75	Prospective	ICU		Yes	Yes	Yes
Sikka et al, 2000 [59]	104	≥75	Prospective	ICU	54.6	No	No	No
Adnet et al, 2001 [60]	79	≥75	Prospective	ICU/CCU	21.6	No	No	No
Ely et al, 2002 [20]	173	≥75	Prospective	ICU	49.7	Yes	Yes	Yes

Abbreviations: CCU, cardiac intensive care unit; ICU, intensive care unit; MICU, medical intensive care unit.

Data from Ely EW, EG, Haponik EF. Mechanical ventilation in a cohort of elderly patients admitted to an intensive care unit. *Ann Intern Med* 1999;131:96–104.

including variations in the process of care offered to elderly patients and concurrent comorbid conditions. Zillerberg and Epstein's study included a majority of patients with major underlying diseases including cancer, cirrhosis, HIV, or transplant-related illness. These conditions were reflected in a higher mortality rate than was seen by Ely et al [14] where these diagnoses were relatively infrequent, underscoring the importance of careful consideration of comorbidities. Other researchers have concurred that a patient's physiologic age, rather than chronologic age may be more closely related to mortality rate [16,17]. This aphorism may appear intuitive but definition of physiologic age in clinically useful, objective terms remains a challenge.

Although prospective appraisals of "all-comers" with acute respiratory failure requiring mechanical ventilation do not support a uniform independent deleterious effect of older age on outcome, consideration of age in specific circumstances is warranted. The cause of respiratory failure may have some influence on its clinical course, response to therapy and mortality rate, but subset analyses addressing these relationships at varying ages are often limited by the small numbers of oldest-old persons. In one report patients admitted to the MICU with exacerbations of COPD had an in-hospital mortality rate of 24% [10]. Patients aged 65 years and older had an in-hospital mortality rate of 30% and a 1-year mortality rate of 59% [10]. On day 1 only 49% of patients required mechanical ventilation. These observed mortality rates might have been higher if more severely ill patients with respiratory failure requiring mechanical ventilation had been studied. In a multivariate analysis the effect of age on both hospital and long-term survival rates were diminished. The length of time in the hospital prior to ICU admission and the development of nonrespiratory failure were the most important determinants of mortality in the multivariate analysis [10].

Luhr et al [18] suggested that both patient age and the specific disease process causing respiratory failure might affect outcomes. In their study, 1231 patients with acute respiratory failure were identified from 132 Scandinavian ICUs. Among these patients 221 met criteria for ARDS and 119 for ALI as defined by American-European Consensus Criteria. The mortality rate of all patients at 90 days was 40%. When age intervals of younger than 45 years, 45 to 74 years, and 75 years and older were examined, there was an age-dependent increase in mortality rate seen in older patients [18]. The age-related increase in mortality rate persisted after multivariate analysis, with those patients aged older than 65 years having a risk ratio of 1.31 (95% CI, 1.18–1.44; $P < 0.0001$). Analysis of data from a multicenter registry of patients with ARDS has shown a higher mortality rate in older patients; 75% of patients aged 60 to 85 years died, in comparison to rates of 62% (ages 50–59 years) and 37% (ages 16–49 years) observed in younger patients. Sepsis was more often the risk factor for the development of ARDS (68% in persons ≥ 60 years versus 54% in persons < 50 years) but this difference was not statistically significant [19]. Thus, for patients with ARDS age appeared to affect outcomes including mortality rates [18]. More recently analysis of patients with ALI and ARDS prospectively studied in the ARDS Multicenter Network demonstrated patient age to be the second most

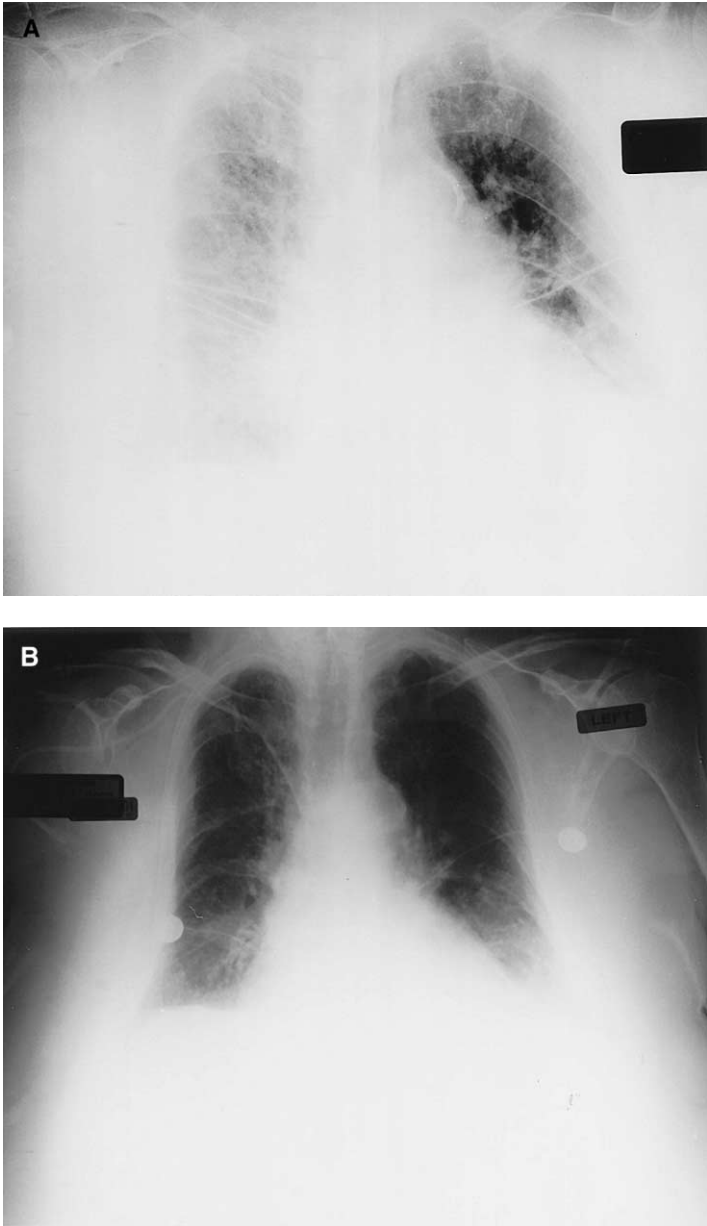


Fig. 4. Chest radiograph showing a 78-year-old female patient who developed a perforated duodenal ulcer requiring laparotomy. On postoperative day 3 (A), she developed increasing respiratory distress and increased F_iO_2 requirements, which necessitated endotracheal intubation and positive pressure ventilation. She had central venous pressures that did not suggest hydrostatic pulmonary edema, and was therefore diagnosed with acute respiratory distress syndrome. She was treated with a low-tidal volume strategy, and was liberated from the ventilator on postoperative day 7. (B) Patient's chest radiograph on postoperative day 8. The patient was discharged home on postoperative day 11.

important determinant of 28-day survival (behind the modified APACHE score) [20]. Ely et al [20] examined the effects of age on achieving physiologic landmarks of recovery and survival in patients with ARDS. Consistent with previous studies, the ability of older persons to pass a spontaneous breathing trial was similar between older and younger patients; however, older patients took longer to be liberated from the ventilator, had longer durations of ICU stay, and had lower 28-day and 180-day survival rates. Patients older than 70 years also had higher rates of reintubation [20]. This observation is consistent with longstanding anecdotal impressions of the lethal impact of ARDS in elderly patients. It should be noted that although patients older than 70 years old had decreased survival, 50% of patients survived 28 days, and 40% survived 180 days. Thus, these data do not suggest that physicians should deny the use of resources or life support in this patient population. A case history and chest radiographs from an older patient with ARDS is seen in Fig. 4.

A recent study evaluated over a 10-year period the clinical course of 23 patients with advanced idiopathic pulmonary fibrosis (IPF) who required mechanical ventilation in a specialized center that performed lung transplantation [21]. Although the mean age of the patients was 53 years the dismal prognosis of their respiratory failure in this setting is relevant to older persons in whom anecdotal experience indicated that progressive IPF generally has a devastating course. In this study 22 of the 23 patients with IPF died while on the ventilator. One patient successfully received lung transplantation but this option is not generally offered to elderly patients (Jon Orens, personal communication, 2001). The nearly uniformly fatal course did not allow determination of whether age was an independent predictor of mortality [21]. Thus, the specific disease process that precipitates respiratory failure may be more important than the age of the patient in determining outcomes.

The association of patient age with the outcome of severe community-acquired pneumonia has been well recognized historically. Recently, Pascual et al [22] assessed prognosis in patients with community-acquired pneumonia requiring mechanical ventilation and identified clinical parameters associated with hospital mortality. Patient age older than 80 years and medical comorbidity (with a prognosis for survival of < 5 years) were independent predictors of mortality along with the number of nonpulmonary organ failures, immunosuppression, and the extent of lung injury.

Leroy et al [23] studied 278 patients aged 65 years or older with severe community-acquired pneumonia admitted to the ICU. Most, but not all of these patients, required mechanical ventilation. Older patients were more likely to be women, have more serious underlying disease, and were more likely to have significant underlying pulmonary disease than were younger patients. Whereas crude mortality rates were higher in those older patients, multivariate analysis was not performed to determine whether age was a predictor of mortality in these patients. Given the increased incidence of comorbidities in the older persons it is not possible to make conclusions about the effects of age on outcome in patients with acute respiratory failure from pneumonia in this investigation.

The important role of comorbidities in the outcomes of elderly patients with respiratory failure is underscored in Swinburne et al's [24] review of 1860 patients, including 282 patients aged 80 years and older. Octogenarians whose respiratory failure was accompanied by renal disease, hepatic failure, systemic illness, cancer and/or chronic gastrointestinal disease with malnutrition had survival of only 7%, compared with 29% survival in younger individuals with similar comorbidities. In the absence of these comorbid conditions, 38% of these octogenarians survived (versus 48% of younger patients). Mechanical ventilation required for more than 15 days was also associated with poorer outcome (9% survival in older patients versus 36% in younger patients).

Costs of mechanical ventilation in elderly patients

Health care costs for patients older than 65 years represent more than one third of the total health care expenditures in the United States [25]. There is little information about whether this large expenditure relates primarily to comorbid conditions and physiologic age or to chronologic age. Knowing whether chronologic age is an important determinant of health care costs would have important policy implications and data specific to respiratory failure are needed.

The costs associated with some aspects of mechanical ventilation of patients with COPD have been reported previously. As in other settings expenditures in the care of older persons with respiratory failure are often lower than those in younger individuals, suggesting differences in the process of care and a less vigorous approach to management [26]. Patients with COPD and acute respiratory failure, however, have been observed to have increased respiratory costs of care when compared with individuals with other causes of acute respiratory failure and these total respiratory costs were higher despite similar lengths of stay and days of mechanical ventilation [26]. Most of the accentuated costs could be attributed to an increased use of nebulizers, metered dose inhalers, and pulse oximetry. Total hospital costs were not different between the two groups. When this experience was examined using multiple linear regression analysis there was no evidence that age was significantly related to respiratory care or total hospital costs.

The cost-effectiveness of prolonged mechanical ventilation of patients with prolonged respiratory failure is a major clinical dilemma. Cohen et al [27] performed a retrospective review of patients older than 80 years who required more than 3 days of mechanical ventilation. Only 10 of the 45 patients studied who required more than 3 days of ventilation survived to leave the hospital. The total costs of these 45 patients were \$2,139,455, with two thirds of the charges occurring after day 3. Little information is provided about the patients' premorbid conditions or details of their care. It is therefore difficult to conclude to what extent the patients' physiologic rather than chronologic age was important.

The cost-effectiveness of vigorous therapeutic approaches in elderly patients has also been addressed by the SUPPORT investigators [28]. In their comprehensive analysis of 1005 patients with acute respiratory failure, including 963

who received ventilator support, they found the latter therapy to be economically worthwhile, even for patients aged 75 years and older, so long as their short-term prognoses were relatively good. For these patients (with > 50% estimated 2-month survival) the incremental cost per quality-adjusted life-year saved by providing aggressive care, including ventilator support, ranged from \$32,000 for patients younger than 65 years to \$46,000 for patients aged 75 years and older. For patients with poor short-term prognoses this management approach was much less cost-effective [28].

Common management issues

In general, few data are available defining the optimum approach to care. As newer approaches to the treatment of older patients with respiratory failure evolve increased attention is needed on the role of age-specific aspects of therapy. Endotracheal intubation is associated with many risks, including traumatic injury from the artificial airway, the development of ventilator-associated pneumonia (VAP), and the need for intravenous catheters to deliver additional medications, including sedative and analgesic agents. In particular, accentuated risks of the latter medications in elderly individuals require a cautious approach. The recent documentation of more expeditious weaning in patients in whom sedation is interrupted on a daily basis [29] appears especially relevant to this patient population.

Among the most feared of nosocomial complications is the development of VAP. Patients who undergo endotracheal intubation become colonized with hospital-acquired microorganisms, which are often resistant to multiple antibiotics, depending on institutional practice patterns. Normal host barriers are bypassed with the endotracheal tube, and the administration of sedative and/or analgesic agents may suppress the cough reflex. Fagon et al [30] prospectively evaluated 52 patients who were shown to have VAP as defined by clinical criteria in addition to quantified bacterial cultures, which were obtained by protective brush specimen with growth of more than 10^3 cfu/mL. This group showed a VAP incidence of approximately 1% per day of endotracheal intubation. A more recent study, by the Canadian Critical Care Trials group suggested that the incidence of VAP is at its highest in the first week of intubation [31]. In meticulous analysis of risk factors for the development of VAP, univariate analysis showed an association of older age on the development of VAP, but this relationship did not remain significant in a multivariate analysis [31]. Kollef et al [32] also showed that increasing age was not associated with increased in-hospital mortality rates in patients with VAP.

Given these complications associated with endotracheal intubation and mechanical ventilation, increased attention has been focused on therapies that might reduce the need for endotracheal intubation. Noninvasive ventilation (NIV) is one such therapy and may also present a less intrusive temporizing option in selected older patients averse to endotracheal intubation [33]. Because the timely use of this modality may obviate the need for endotracheal intubation altogether the use

of NIV in selected elderly patients may have particular appeal. In prospective investigations carefully selected patients with acute exacerbations of COPD treated with NIV have decreased need for endotracheal intubation, decreased length of ICU stay, and improved survival rates [34,35]. A recent study in England showed that the use of bilevel positive airway pressure (BiPAP), in patients on a general medical ward was associated with a reduced need for endotracheal intubation and lower mortality rates [36]. This study was notable because this intervention was performed on a ward without specialized training. The mean age of patients in the treatment and control groups was 69 years. This therapy demands appropriate respiratory therapy support staff and is not appropriate for use in patients with altered mental status, in patients with copious secretions, or in patients with hemodynamic instability. Moreover, many older patients find the mask and pressure confining and uncomfortable and do not tolerate the intervention [37]. Accordingly, some patients in whom this therapy is tried require conversion to invasive mechanical ventilation with endotracheal intubation. In general, patients in whom NIV is attempted should be monitored closely in an area of the hospital where conversion to endotracheal intubation and invasive mechanical ventilation may be done quickly [37].

Chronic respiratory failure in elderly patients

Some patients with acute respiratory failure cannot be successfully liberated from the ventilator within the first 2 to 3 weeks of hospital stay [38]. These patients, designated as having chronic respiratory failure, undergo tracheostomy for long-term airway maintenance and when the acute causes of hospitalization are resolved often are transferred to a long-term care facility. These patients tend to have a higher short- and long-term mortality than individuals who are successfully liberated from the ventilator in the ICU. Not all patients desire long-term mechanical ventilation and many patients have expressed the belief that death would be a preferable outcome. For those patients with acute respiratory failure who are not liberated from the ventilator within the first 2 to 3 weeks of intubation consideration of terminal weaning with concomitant use of opiates for the relief of dyspnea may be appropriate.

Although it is clear in the acute hospital setting that a weaning protocol implemented by respiratory care professionals and nursing staff reduces the length of mechanical ventilation, the optimal mode of weaning elderly patients with chronic respiratory failure is not known. The authors and other physicians have therefore initiated a respiratory therapy–driven protocol in the long-term care setting to appraise whether such a protocol would be useful, effective, and safe in this patient population. On admission to the 27-bed ventilator unit of the Johns Hopkins Geriatric Center patients undergo screening for medical stability and definition of realistic goals of care and an individualized plan. A multidisciplinary assessment is performed by geriatricians, pulmonary/critical care physicians, nursing staff, physical therapists, nutritionists, and respiratory care

professionals. Measurements of simple weaning parameters are performed on these patients. Spontaneous breathing trials are started for those patients meeting the following criteria: $F_{I}O_2$ requirements less than 0.50, a negative inspiratory pressure greater than -20 cm, a respiratory rate of less than 35, and spontaneous tidal volume greater than 250 mL (Fig. 5).

AC/T-piece WEAN

1. Notify patient's nurse
2. Increase $F_{I}O_2$ by 0.1
3. RT in room for 1st 30 mins 1st day
4. Watch for signs of failure
5. ABG at end of first trial

- First day aim for 15 mins
 - up to 2 hrs if patient tolerates extremely well
- Aim to double duration Q d
- If pt. fails, complete rest \times 24 hrs then re-try at shorter duration
- If pt. fails again, complete rest \times 48 hrs then re-try at shorter duration
- If pt. repeatedly fails or reaches plateau:
 - longer complete rest period (e.g. 48 hrs)
 - optimizing medications (e.g. theophylline)
 - adding/increasing anxiolytics
 - CPAP wean (5 cm H_2O if auto-peep present)
- If no progress after 1-2 weeks, use IMV \pm PSV wean

IMV/PSV WEAN

1. Notify patient's nurse
2. Increase $F_{I}O_2$ by 0.1
3. Decrease IMV by 2 bpm or PSV by 2-3 cm H_2O
4. Watch for signs of failure

- Aim to decrease IMV by 2 bpm QD, or
- Aim to decrease PSV 2-3 cm H_2O QD
- T-piece if on IMV \leq 4 bpm \pm PSV \leq 5 cm H_2O
- If pt. initially fails, rest \times 24 hrs then re-try
- If pt. fails again, consider:
 - longer complete rest period (e.g. 48 hrs)
 - optimizing medications (e.g. theophylline)
 - adding/increasing anxiolytics
 - adding PEEP (5 cm H_2O if auto-peep present)
- If pt. repeatedly fails, consider longer rest period in conjunction with team

Signs of weaning failure

- RR $>$ 35 breaths/min
- HR $>$ 140 beats/min
- SaO_2 $<$ 90%
- Systolic BP $>$ 180 or $<$ 90 mmHg
- anxiety, chest pain, diaphoresis or somnolence
- decreasing alveolar MV and increasing ETCO₂

Fig. 5. Weaning flowsheet for patients with chronic respiratory failure admitted to the Johns Hopkins Ventilator Weaning Unit. This core approach is modified further for each patient's needs on the basis of observations by the weaning team. *Abbreviations:* ABG, arterial blood gas; AC/T, assist control/tracheostomy; BP, blood pressure; CPAP, continuous positive airway pressure; ETCO₂, end-tidal CO₂; HR, heart rate; IMV, intermittent mandatory ventilation; MV, minute ventilation; PSV, pressure support ventilation; Q, every; QD, every day; RR, respiratory rate.

Over a 22-month period 89 patients (mean age, 65) were admitted to this specialized unit. The most common diagnosis was primary respiratory failure with a smaller subset of patients having neurologic, sepsis, and metabolic issues. Despite the complexity of their illnesses 22 patients (25%) were liberated successfully from the ventilator. Increased age was not associated with weaning failure; the mean age of those patients successfully weaned was slightly older than those who continued to require mechanical ventilation. Thus, respiratory care professionals using spontaneous breathing trials in elderly patients with chronic respiratory failure in a long-term care setting providing comprehensive general care can successfully implement a standardized weaning protocol [39]. The optimum use of this strategy and development of validated criteria for patient selection are needed.

In certain circumstances elderly patients with chronic respiratory failure who remain ventilator-dependent may be cared for effectively at home. Home-based mechanical ventilation has many potential advantages. These include the avoidance of some of the nosocomial risks of therapy associated with admission to a ventilator unit (eg, “sundowning,” development of colonization with resistant organisms and *Clostridium difficile* colitis). The amount of support and care that these patients require is tremendous. Prior to being discharged home family members must acquire numerous essential skills including performing tracheostomy care, delivering necessary medications, such as bronchodilators, and troubleshooting ventilator problems. They must also maintain someone at home with the patient at all times. In the authors’ experience it is the rare family that is able to marshal the social, physical, and financial support to manage a patient with persistent respiratory failure at home. For those few who are able to do so, however, this potentially represents a useful alternative to placement in a long-term care facility. Few studies compare these approaches but our anecdotal experience suggests that the incidence of superimposed infections by multi-resistant organisms may be diminished in those patients with chronic respiratory failure who are cared for at home. More information regarding home care for chronically and critically ill elderly patients is needed.

Summary

Elderly individuals comprise an increasing proportion of the population and represent a progressively expanding number of patients admitted to the ICU. Because of underlying pulmonary disease, loss of muscle mass, and other comorbid conditions, older persons are at increased risk of developing respiratory failure. Recognition of this vulnerability and the adoption of proactive measures to prevent decompensation requiring intrusive support are major priorities together with clear delineation of patients’ wishes regarding the extent of support desired should clinical deterioration occur. Further, the development of coordinated approaches to identify patients at risk for respiratory failure and strategies to prevent the need for intubation, such as the use of NIV in appropriate patients,

are crucial. As soon as endotracheal intubation and mechanical ventilation are implemented strategies that facilitate the liberation of elderly patients from the ventilator are especially important. The emphasis on a team approach, which characterizes geriatric medicine, is essential in coordinating the skills of multiple health care professionals in this setting.

Respiratory failure can neither be effectively diagnosed nor managed in isolation. Integration with all other aspects of care is essential. Patient vulnerability to nosocomial complications and the “cascade effect” of these problems such as the effects of medications and invasive supportive procedures all impact on respiratory care of elderly patients. For example, prolonged mechanical ventilation may be required long after resolution of the underlying cause of respiratory failure because of unrecognized and untreated delirium or residual effects of small doses of sedative and/or analgesic agents or other medications in elderly patients with altered drug metabolism. The deleterious impact of the foreign and sometimes threatening ICU environment and/or sleep deprivation on the patient’s course are too often overlooked because the physician focuses management on physiologic measurements, mechanical ventilator settings, and other technologic nuances of care [40].

Review of the literature suggests that the development of respiratory failure in patients with certain disease processes such as COPD, IPF, and ARDS in elderly patients may lead to worsened outcome but it appears that the disease process itself, rather than the age of the patient, is the major determinant of outcome. Additional studies suggest that other comorbid factors may be more important than age. Only when comorbid processes are taken into account should decisions be made about the efficacy of instituting mechanical ventilation. In addition, because outcome prediction appears to be more accurate for groups of patients rather than for individual patients a well-structured therapeutic trial of instituting mechanical ventilation, even if comorbidities are present, may be indicated in certain patients if appropriately informed patients wish to pursue this course. This approach requires careful and realistic definition of potential outcomes, focus on optimizing treatment of the reversible components of the illness, and continuous communication with the patient and family.

Although many clinicians share a nihilistic view regarding the potential usefulness of mechanical ventilation in elderly patients few data warrant this negative prognostication and more outcome studies are needed to delineate the optimum application of this element of supportive care. As with other interventions individualization of the decision must take into account the patient’s premorbid status, concomitant conditions, the nature of the precipitating illness and its prospects for improvement, and most important, patient preferences. In this determination pursuing the course most consistent with the patient’s wishes is essential and it must be appreciated that caregivers’ impressions regarding the vigor of support desired by the patient are often erroneous. The SUPPORT investigators observed that clinicians often underestimated the degree of intervention desired by older patients assuming that less care would be desired [13]. Thus, as in other circumstances, effective communication and elicitation of

patients' preferences regarding management options is crucial in the management of respiratory failure. The frequent discordance between patient preferences and the wishes of family members or other surrogate decision makers impose major clinical challenges and also mandates further investigation.

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