A multidisciplinary team approach to weaning from prolonged mechanical ventilation

Objective: To establish whether multidisciplinary team-led strategies to maintain continuity across the weaning process result in an increase in the proportion of patients surviving prolonged mechanical ventilation and reduce the length of time patients are ventilated.

Design: A quality improvement programme was conceived and implemented for patients receiving mechanical ventilation for ≥21 days.

Setting: University teaching hospital general intensive care unit.

Interventions: The introduction of long-term weaning plans.

Measurements and main results: intensive care unit survival odds ratio and 95% confidence interval 0.181 (0.06–0.49) $P<0.01$ and hospital survival odds ratio and 95% confidence interval 0.2 (0.08–0.61) $P<0.01$. Duration of mechanical ventilation (median and 95% confidence interval) 53 days (32–74) *vs* 42 days (39–44) $P=0.03$.

Conclusions: Long-term weaning plans led by a multidisciplinary team were associated with a reduction in intensive care unit and hospital mortality, and duration of mechanical ventilation in patients ventilated for ≥21 days. Strategies to maintain continuity in this complex patient group are likely to be fundamental to improving outcome.

Weaning from prolonged mechanical ventilation presents a complex challenge to the critical care multidisciplinary team. Until recently, comparison of management strategies for weaning has been complicated by discrepancies in the populations being described (Cox et al, 2007). Prolonged mechanical ventilation has been defined as 'the need for ≥21 consecutive days of mechanical ventilation for ≥6 hours per day' (MacIntyre et al, 2005). The use of this definition now permits comparisons to be made between different strategies. However, there is still no commonly accepted best method of weaning from prolonged mechanical ventilation (MacIntyre et al, 2005; Brochard and Thille, 2009). This is reflected in practice by the many approaches to weaning, even within the same intensive care unit. In the authors' experience a single patient can often be exposed to several different weaning approaches during his/her recovery from critical illness.

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Of 17 640 intensive care unit admissions mechanically ventilated in the UK in the 2 years up to 31 March 2008, 2.7% were ventilated for ≥21 days, but they accounted for 30.8% of ventilator bed days (Intensive Care National Audit and Research Centre, personal communication, 2008). The mortality (Cox et al, 2007) and physical dependence (van der Schaaf et al, 2008) associated with increasing duration of mechanical ventilation and the increasing body of evidence describing the unpleasant patient experience of prolonged mechanical ventilation (Rotondi et al, 2002; Johnson et al, 2006) provide a compelling argument to find an effective management strategy for these patients.

Patients requiring prolonged mechanical ventilation are a heterogeneous group, often with multiple comorbidities and a wide range of primary insults that dictate the need for mechanical ventilation (Nierman, 2002). Although patients generally receive an individualized approach to the management of their critical illness (Smith and Shneerson, 1995; Henneman et al, 2001), a consistent and coordinated approach still needs to be applied to their weaning plan.

Continuity is often difficult to provide because of staff rotas (Waite et al, 2009) and a lack of consistency between different consultants can lead to frequent changes in weaning strategies. The lack of defined local frameworks also hinders coordination of the process of care delivery (Nierman, 2002). Several groups have sought to address this problem through protocols (Girard and Ely, 2008). However, the debate regarding the use of protocols within health care continues and, even when implemented, staff compliance is often poor (DeMonaco, 2000). Weaning protocols are not widely accepted for similar reasons, including lack of clinical autonomy and fear of 'cookbook medicine' (Blackwood et al, 2004).

There is sparse evidence describing best management of patients requiring prolonged mechanical ventilation in the general intensive care unit (Smith and Shneerson, 1995). Data and guidance are limited to long-term acute care centres, specialist respiratory care units in North America (Gracey et al, 1997; Dasgupta et al, 1999; Bigatello et al, 2007; Epstein, 2007; Scheinhorn et al, 2007) and specialized respiratory or weaning centres in Europe (Nava, 1998; Vitacca et al, 2001; Schonhofer et al, 2002; Pilcher et al, 2005). It is important to acknowledge the differences in practice, skill, casemix and structure of care provided between these and general intensive care units (Subbe et al, 2007). However, a general consensus is that reductions in 'uncontrolled clinical practice' and standardization of approaches are associated with a greater weaning success rate (Vitacca et al, 2001).

Collaborative multidisciplinary team plans that respect the individual contribution of all intensive care unit team members have demonstrated small-scale improvements in patient outcomes (Henneman et al, 2001; O'Bryan et al, 2002; Kim et al, 2010). Failure to embrace interdisciplinary collaboration and to recognize that each discipline can offer an important contribution to care delivery (Yeager, 2005) may impact upon the management of patients receiving prolonged mechanical ventilation.

On the authors' 27-bedded, university teaching hospital intensive care unit there was a lack of continuity in strategies to wean patients from prolonged mechanical ventilation, despite a strong multidisciplinary team approach to other aspects of care. This article describes their 3-year experience of addressing this variability in care through a quality improvement process.

They hypothesized that multidisciplinary team-led strategies to maintain continuity across the weaning process:

- Are feasible within a general intensive care unit
- Would result in an increase in the proportion of patients surviving prolonged mechanical ventilation
- Would reduce the length of time patients remained on a ventilator.

Process

This was a clinical audit of patients receiving mechanical ventilation for ≥21 days. Mechanical ventilation was defined as receiving any form of support from a ventilator (e.g. pressure control ventilation, pressure support ventilation or continuous positive airways pressure). For patients who required re-ventilation within the same intensive care unit admission, the total cumulative duration of ventilation was used.

A multidisciplinary-led, long-term care group was established, which initially consisted of a physiotherapist, nurse consultant, dietician, and speech and language therapist. The group met weekly to create long-term weaning plans for individual patients who had been ventilated for ≥21 days (*Table 1*). These strategies were based on team consensus and drew on elements from weaning strategies used by long-term acute care centres or specialist respiratory care units in North America and from regional weaning centres in the UK. These plans were then agreed with the clinical team, translated into a written plan and reviewed on a weekly basis or sooner if the patient's condition changed.

The clinical audit included four groups of patients:

- Year 1 (July 2004–June 2005): preceding introduction of long-term weaning plans
- Year 2 (July 2005–June 2006): introduction of long-term weaning plans for patients who had failed three or more attempts at weaning from mechanical ventilation
- Year 3 (July 2006–June 2007): an increase in the number of patients enrolled on long-term weaning plans
- Year 4 (July 2007–June 2008): standard practice intensive care unit includes use of long-term weaning plans.

Data were collected retrospectively from electronic records at the end of each year. If a patient was mechanically ventilated more than once for ≥21 days over the 4-year period of the audit, then only the first episode within this period was included.

The two primary outcome measures were survival from mechanical ventilation after day 21 of mechanical ventilation and the number of days ventilated (from day of intubation to the first 24-hour period when no ventilatory support was required).

The 4 years were assessed for comparability using the following baseline variables: gender, age on admission to intensive care unit, severity of disease on admission to intensive care unit (APACHE II), and clinical case mix, in particular a history of chronic obstructive pulmonary disease and ischaemic heart disease. Categorical variables were analysed using the chi-squared test. Continuous variables were analysed by one-way analysis of variance, as the data were normally distributed.

Survival was analysed using a generalized linear model with survival as the binary outcome, this was offset for the length of time ventilated. The data were offset for the length of time ventilated to account for the opportunity for an event to occur, changing with the length of time ventilated, i.e. the longer a patient was in the intensive care unit the greater the opportunity there was for an event to occur. Age on admission to intensive care unit, APACHE II, gender, and audit year were the explanatory variables. The results are reported as odds ratios with 95% confidence limits.

The number of days ventilated after day 21 was analysed using survival techniques. Data were censored at death. For single variable analysis, Kaplan–Meier curves were plotted for each year and time ventilated compared with the log-rank test. All baseline analyses were considered statistically significant at the 5% level and the two primary outcome analyses variables – intensive care unit mortality and duration of mechanical ventilation – were considered statistically significant at the 2.5% and 1.66% levels respectively (Bonferroni correction for multiple outcomes).

Results

In total, 146 patients ventilated for ≥21 days were included in the analysis. Exclusions were because of previous episodes of

Table 1. Description of long-term weaning plans
Overnight rest: increasing pressure support to maintain a respiratory rate <24 breaths/min, a normal pH and tidal volume ≥5 ml/kg body weight
Daily target-driven reductions in pressure support
Rest days for patients who are considered to be consistently failing to wean
Tracheotomy mask trials of increasing duration with the cuff deflated and a speaking valve in situ
An individual functional rehabilitation programme focusing on achieving the highest level of mobility and encouraging participation in activities of daily living
A communication strategy enabling the patient to phonate at the earliest opportunity. If this is not possible because of high levels of ventilatory support or insufficient subglottic flow, the team endeavour to provide writing tools or alphabet boards
A nutritional regimen aiming to match increasing levels of activity and to facilitate the transition between nasaogastric and oral intake
Care aiming to maintain continuity in the allocation of the bedside nurse and physiotherapist

Table 2. Numbers of patients mechanically ventilated ≥21 days in each of the four time periods

Year		1	2	3	4
Initial sample size		40	41	35	39
Excluded because previous episode of mechanical ventilation lasted ≥21 days		1 (survived)	0	1 (died)	2 (died)
Lost to follow up		0	4 (transferred out of ICU still ventilated)	1 (transferred to a regional weaning centre)	0
Final sample		39	37	33	37
Long-term weaning plan n (%)		0 (0%)	10 (27%)	20 (60.6%)	30 (81.1%)
Gender (M:F)		22:17	17:20	18:15	18:19
Age mean (SD) (years)		61.4 (16.8)	60.7 (16.2)	65.9 (15.9)	65.0 (15.9)
APACHE II mean (SD)		24 (8)	26 (9)	26 (10)	27 (8)
Comorbidities	COPD	3	9	5	4
	Ischaemic heart disease	9	3	9	9

COPD = chronic obstructive pulmonary disease; ICU = intensive care unit; SD = standard deviation.

Table 3. Intensive care unit mortality*

Variable	Intensive care unit mortality	Odds ratio adjusted for covariates	95% confidence interval for odds ratio	*P* value
Year 1	64%	1	–	–
†Year 2	41%	0.27	0.10–0.72	0.01
†Year 3	24%	0.106	0.03–0.31	0.0001
†Year 4	35%	0.181	0.06–0.49	0.001
Male	–	1.03	0.49–2.17	0.94
Female	–	1	–	–
Age	–	1.022	1.00–1.05	0.09
APACHE II	–	1.017	0.97–1.07	0.46

* Generalized linear model (†statistical significance at 2.5% level Bonferroni correction). Each year is compared to year 1.

Table 4. Hospital mortality*

Variable	Hospital mortality	Odds ratio adjusted for covariates	95% confidence interval for odds ratio	*P* value
Year 1	72%	1	–	–
Year 2	57%	0.39	0.14–1.07	0.07
†Year 3	33%	0.11	0.04–0.31	0.0001
†Year 4	49%	0.22	0.08–0.61	0.004
Male	–	1.13	0.54–2.37	0.74
Female	–	1	–	–
Age	–	1.02	0.98–1.07	0.34
APACHE II	–	1.03	1.00–1.05	0.03

* Generalized linear model (†statistical significance at 2.5% level Bonferroni correction). Each year is compared to year 1.

mechanical ventilation for ≥21 days and loss to follow up. Patient demographics in each year were similar for age, gender, APACHE II scores and comorbidities of chronic obstructive pulmonary disease and ischaemic heart disease (*Table 2*). The proportions of patients ventilated between ≥24 hours and up to 14 days, between 14–21 days, and for ≥21 days remained the same over the 4-year audit period (*P*=0.72). All patients discharged from the intensive care unit were ventilator-independent with the exception of four patients in year 2 who remained ventilated on transfer from the hospital, and one patient in year 4 who was transferred to a regional weaning centre.

Over the 3-year intervention period, intensive care unit (*Table 3*) and in-hospital mortality (*Table 4*) reduced in this patient group. When a generalized linear model was used to account for the covariates of age, gender and APACHE II score, the only factor associated with a reduction in intensive care unit mortality was the year in which the patient was ventilated (*Table 3*).

Kaplan–Meier analysis (*Figure 1*) censuring for death and using log-rank as the test statistic demonstrated a significant (*P*=0.03) reduction in median duration of mechanical ventilation (*Table 5*).

Discussion

This series of clinical audit cycles assessed the effect of a multidisciplinary team-led approach to the management of patients receiving prolonged mechanical ventilation in a general teaching hospital intensive care unit. The data showed that the introduction of long-term weaning plans was associated with a significant improvement in survival and reduction in the duration of ventilation.

This was a quality improvement project and although other factors may have been responsible for the improved outcomes the authors attribute the findings of this quality improvement programme primarily to improvements in continuity of care for this patient group. As the number of professionals involved in the provision of an individual's care increases, so does the challenge of joining up the multiple sources of care to provide a smooth continuum (Haggerty et al, 2003). The aspects of continuity addressed were transfers of information, continuity of staffing and manage-

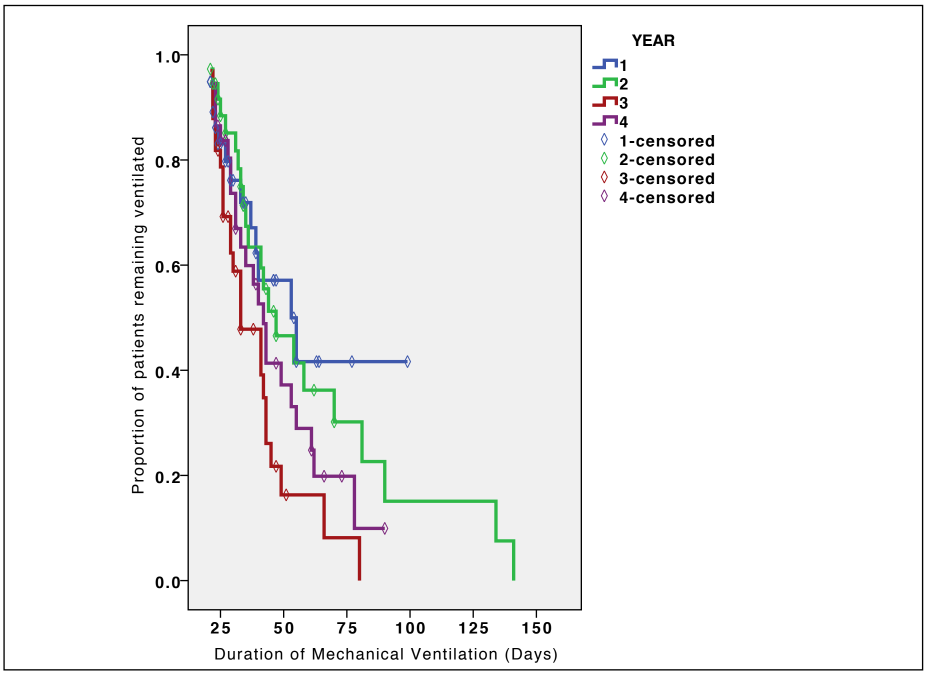

Figure 1. Kaplan–Meier analysis of duration of mechanical ventilation.

ment strategies. Continuity of management strategies was the primary focus of this intervention. This was maintained by creating explicit individual management plans to ensure consistency. By year 4, 80% of patients ventilated for ≥21 days had a long-term weaning plan created, which was updated on a weekly basis.

Informational continuity was improved through weekly team discussions, documentation of the patient's progress, and a clearly defined and documented plan for the subsequent week. These plans aimed to include transfer of knowledge of a patient's preferences, the least likely aspect of care to be shared or transferred between different care providers (Anderson and Helms, 2000). This communication not only has a direct impact on the appropriateness of care for the patient but has been related to higher satisfaction with care (Hjortdahl, 1992). The team also endeavoured to improve staffing continuity by coordinating teams of nurses who regularly looked after individual patients and ensured that the patient had the same physiotherapist throughout the intensive care unit stay.

Other hypotheses for the improvement in survival include the engagement of the whole multidisciplinary team in the process of weaning and/or the team focusing on reasons for failure to wean, but further work needs to be carried out assessing the adherence to the plans and the associated impact. The long-term weaning plans allowed the team to balance care between weaning from mechanical ventilation and exercise to improve function and mobility. The relative importance of the individual elements of the long-term weaning plans, namely a standardized weaning strategy, nutrition, communication and exercise, in the process of weaning remains unclear, although these are likely to be interdependent on each other.

The team endeavoured to fully embed the long-term weaning plans as accepted practice on their intensive care unit through teaching sessions, annual auditing and reporting back to all staff on the outcomes which demonstrated sustained improvements over time.

Implementing the long-term weaning plans did lead to reduced clinical autonomy for medical staff. However, as the proportion of patients enrolled on long-term weaning plans increased year-by-year, this suggests an increased acceptance of this approach to weaning by the consultant intensivists who continue to embrace this concept.

Table 5. Median duration of mechanical ventilation

Year	Median (days)	95% confidence interval: Lower bound	95% confidence interval: Upper bound	P value
1	53	32.1	73.9	–
2	47	30.6	63.4	0.75
*3	33	23.0	43.1	0.01
4	42	36.0	48.0	0.21
Overall	42	39.3	44.7	0.03

* statistical significance at 1.66% level Bonferroni correction.

Further work needs to be carried out to assess the degree of adherence to the plans with the associated impact. Given that long-term weaning plans are now established as the unit's normal practice, it would be difficult to conduct a randomized controlled trial. However, it is hoped that this article will stimulate others to examine their practices and outcomes.

Conclusions

Long-term weaning plans led by a multidisciplinary team were associated with a reduction in both intensive care unit and hospital mortality in patients ventilated for ≥21 days. Strategies to maintain continuity in this complex patient group are likely to be fundamental to improving outcome. They have a high degree of acceptability and can be sustained by cultural changes in practice. **BJHM**

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LEARNING POINTS

- Multidisciplinary team-led strategies to maintain continuity across the weaning process are feasible within a general intensive care unit.
- Multidisciplinary team long-term weaning plans are associated with a reduction in both intensive care unit and hospital mortality in patients ventilated for ≥21 days.
- Strategies to maintain continuity in this complex patient group are likely to be fundamental to improving outcome.

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