Criteria for weaning from mechanical ventilation
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Authors' objectives
The review addresses five questions:

When should weaning be initiated?

What criteria should be used to initiate the weaning process?

What are the most effective methods of weaning from mechanical ventilation?

What are the optimal roles on nonphysician health care professionals facilitating safe and expeditious weaning?

What is the value of clinical practices algorithms and computers in expediting weaning?

Searching
The following databases were searched from 1971 to 1998 (the search strategies used were provided in the report): MEDLINE, EMBASE, HealthSTAR, CINAHL, the Cochrane Controlled Trials Register and the Cochrane Database of Systematic Reviews. The authors also examined reference lists, handsearched Respiratory Care (from 1997 to 1999), and searched their personal files. The authors did not search for unpublished studies.

Study selection
Study designs of evaluations included in the review
RCTs, controlled clinical trials, observational studies, qualitative studies of the patients’ and nurses’ experience of weaning, and quantitative studies describing the patients’ experiences of weaning were included. Single case reports and case series or observational studies with fewer than 20 patients were excluded, as were unpublished doctoral theses.

Specific interventions included in the review
Studies of any ventilation or weaning strategy designed to facilitate weaning and/or extubation were considered for inclusion. Interventions that focused on mechanical ventilation methods not directly relating to weaning, and interventions (e.g. sedation in the intensive care unit and optimal timing of tracheostomy) whose influence on the duration of ventilation has already been summarised in a previous systematic review (reference details were not provided), were excluded. Studies evaluating anaesthesia and sedation management that is integral to testing the effect of early versus late extubation in cardiac surgery patients were included. Interventions that were initiated at the onset of mechanical ventilation were excluded. Examples of the type of strategies examined by the included studies were mode, method, protocol, timing, operator, computer, tracheostomy, noninvasive ventilation modes, adjuvant holistic aids, and other miscellaneous approaches.

Participants included in the review
All studies of adult and paediatric patients who were mechanically ventilated and had either an endotracheal tube or tracheostomy tube were considered for inclusion. Studies of highly specific populations, studies focusing on ventilation-associated pneumonia, and studies of neonates were excluded. Only studies conducted in intensive care units (ICUs), intermediate care units, stepdown units, and post-anaesthetic recovery rooms were included. Studies of home ventilation for children or adults and chronic ventilation settings were excluded.

Outcomes assessed in the review
Predictors of weaning and/or extubation success, and predictors of the duration of weaning in patients with chronic obstructive pulmonary disease or patients following cardiac surgery, were considered for inclusion. Predictors of self-extubation were excluded. Studies designed to evaluate the reproduction of various predictors of weaning success or duration of ventilation were excluded.
All clinical outcome measures were considered for inclusion, whilst studies that reported exclusively on physiological outcomes were excluded. Any study reporting on the patients’ experiences and nurses' assessment of the patients’ experience were included. The outcomes from randomised controlled trials (RCTs) where at least 20% of the patients were eliminated from the analysis were excluded.

How were decisions on the relevance of primary studies made?
Two reviewers assessed unmasked articles for inclusion and any disagreements were resolved by consensus.

Assessment of study quality
The quality of each study was rated using separate pre-specified lists of criteria developed for RCTs, non-randomised controlled trials, studies assessing the predictors of weaning success and duration of ventilation, and qualitative studies. The lists of criteria were given in the report. Two reviewers assessed the methodological quality of each study, and any disagreements were resolved by discussion or consultation with one of the investigators.

Data extraction
Two reviewers abstracted the data, and any disagreements were resolved by discussion or consultation with one of the investigators. The final data extraction was re-checked by one of the investigators.

For randomised and non-randomised studies of weaning interventions, the relative risk and 95% confidence interval (CI) were calculated for binary outcome measures and the mean difference and 95% CI for continuous variables. Interquartile ranges were transformed into standard deviations (SDs) when necessary, to obtain variance estimates for differences between the groups. Where the variance could not be estimated then the CIs were not reported.

For observational studies concerning the predictors of successful weaning and duration of ventilation, where possible the data were abstracted to construct 2x2 tables, from which the sensitivity and specificity (with 95% CIs) of the tests, the odds ratios (and 95% CIs) and the associated likelihood ratios were calculated.

Methods of synthesis
How were the studies combined?
For controlled comparisons of weaning interventions, the RCTs were pooled (i.e. only if the authors judged the studies to be similar enough that they would be expected to produce more or less the same treatment effect) using a random-effects model, but no statistical pooling was performed for non-randomised controlled trials.

For observational studies addressing the predictors of successful weaning and duration of ventilation, the studies were categorised according to the outcomes of interest. Predictors were defined as relevant if they showed potential for differentiating success from failure. All predictors for which the results were presented as 2x2 tables with an associated likelihood ratio of greater than 2 or lower than 0.5 were retained. When the results were presented as means and SDs of the success and failure groups, predictors were included if the difference in means between the two groups was greater than one-half of the smaller of the SDs of the two groups. Where appropriate, and if it made clinical sense, the observational data were pooled. If more than three studies examined a predictor with plausible and clinically important test properties, a summary receiver operator characteristic curve was plotted. Predictors that were identified as important (by a p-value <0.05 in a regression analysis), but for which no further data were given, were summarised in a separate table.

Other types of studies, e.g. qualitative studies examining the experiences of health workers, were combined in a narrative summary. The studies were classified according to study design and topic.

How were differences between studies investigated?
Differences between the studies were discussed in a narrative summary.

Where pooling was considered feasible, statistical heterogeneity of RCTs was investigated using a test based on the chi-squared distribution. When clinically important heterogeneity was present, which could not be explained by chance, the authors reviewed the methodology of the original studies in order to find any explanation for the differences in
outcomes.

**Results of the review**

One hundred and fifty-four articles (150 studies) were included, of which 46 were RCTs and 25 were non-randomised controlled trials.

**Weaning interventions:**

The studies showed that for stepwise reductions in mechanical support, pressure support mode or multiple daily T-piece trials could be superior to synchronised intermittent mandatory ventilation. For trials of unassisted breathing, low levels of pressure support could be beneficial. There may be substantial benefits to early extubation and institution of noninvasive pressure ventilation before patients are ready to breath without mechanical assistance. The value of differing modes appears to depend on the thresholds for initiating, progressing through, and terminating weans in the specific study protocols. However, these thresholds are not completely based on objective data and appear to be related to physician judgement.

The implementation of nurse-driven or respiratory therapy-driven weaning protocols, regardless of what modes are employed, speed up the initiation of weaning and appears to be safe. Following cardiac surgery, early extubation is clearly achieved with a variety of anaesthetic interventions and ICU protocols. However, the corresponding reduction in ICU stay is generally small and the impact on complications, though rare, remains unclear. The role of computerised protocols has not been established.

**Predictors.**

No consistently powerful weaning predictors were identified. The most frequently studied and one of the most helpful test was the rapid shallow breathing index; however, the pooled likelihood ratio for a positive test ranged from 1.3 to 2.8. Two other predictors, occlusion pressure/maximum inspiratory pressure and the compliance, rate, oxygenation and pressure index were more powerful, though less intensely studied. In general, the probable reason for the poor performance of weaning predictors is that physicians are aware of the results of these predictors when they select patients for study.

**Authors' conclusions**

Explicit protocols that begin testing for the opportunity to reduce support after intubation and reduce support at every opportunity have consistently performed as well or better than intuitive approaches, when formally tested in appropriate patients. For most methods of weaning, the impact may be small in relation to the criteria used for the reduction and discontinuation of support. Weaning protocols implemented by respiratory therapists and nurses are likely to reduce the duration of mechanical ventilation and may reduce the length of ICU stay, and thus the health care resource consumption. Computer algorithms have received minimal study and have attendant logistic barriers.

**CRD commentary**

The review addresses an appropriate question using clear inclusion and exclusion criteria. The literature search was comprehensive, although unpublished studies were not considered for inclusion and the authors did not assess whether publication bias may have affected the results. Two reviewers independently assessed the studies for inclusion, performed the data extraction and assessed the quality of the included studies. This would have helped to reduce any errors and minimise bias. Relevant data from the included studies were tabulated and the studies were combined appropriately. The authors' results appear to follow from the results presented.

**Implications of the review for practice and research**

**Practice:** The authors did not state any implications for practice.

**Research:** The authors state a number of implications of research. Future research should determine the optimal trade-off between prolonged time on a ventilator and reintubation in specific patient groups; further evaluate weaning...
protocols (What type of patients are most likely to benefit? Which protocols are most effective? How large are the associated cost reductions); question whether there is a role for computers; and clarify the risk-benefit of early extubation with noninvasive positive pressure ventilation.

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**Record Status**
This is a critical abstract of a systematic review that meets the criteria for inclusion on DARE. Each critical abstract contains a brief summary of the review methods, results and conclusions followed by a detailed critical assessment on the reliability of the review and the conclusions drawn.