An economic evaluation of prolonged mechanical ventilation

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Record Status
This is a critical abstract of an economic evaluation that meets the criteria for inclusion on NHS EED. Each abstract contains a brief summary of the methods, the results and conclusions followed by a detailed critical assessment on the reliability of the study and the conclusions drawn.

Health technology
The study examined prolonged mechanical ventilation (PMV) for at least 21 days with placement of a tracheostomy for non-ear, nose and throat diagnosis in critically ill patients admitted to an intensive care unit (ICU). This was compared with a strategy of withdrawal of mechanical ventilation between day 7 and day 21.

Type of intervention
Other: Supportive care.

Economic study type
Cost-effectiveness analysis, cost-utility analysis

Study population
The study population comprised a hypothetical cohort of 65-year-old critically ill patients.

Setting
The setting was an ICU. The economic study was carried out in the USA.

Dates to which data relate
The clinical and economic data were derived from studies published between 1999 and 2007. The price year was 2005.

Modelling
A Markov model was used to model the costs and benefits of the two approaches under examination. The timeframe of the analysis was lifetime, with weekly cycles. The structure of the model, the health states and details on transition patterns were described and represented graphically. Long-term survival curves were created using the declining exponential approximation of life expectancy method. A probabilistic analysis was carried out, and the statistical distributions assigned to model parameters were briefly reported.

Study designs and other criteria for inclusion in the review
The clinical data used in the decision model were:

- the probability of discharge from hospital to home, a long-term acute care (LTAC) facility, a skilled nurse facility (SNF), or inpatient rehabilitation;
- the probability of discharge from an LTAC to home, a hospital (readmission), an SNF, or inpatient rehabilitation;
- the probability of discharge from SNF to home, a hospital (readmission), a long-term nursing home with or without ventilation, or inpatient rehabilitation;
- the probability of discharge from inpatient rehabilitation to home, a hospital (readmission), or a nursing home;
- mortality during initial hospital stay or readmission, at home, or in an SNF or LTAC;
- rates of readmissions; and
- expected survival.
Sources searched to identify primary studies
With the exception of an observational cohort study of 817 persons who received mechanical ventilation for more than 48 hours at the University of Pittsburgh Medical Center, the characteristics of the studies used to derive clinical estimates were not described. This source was used only for data on survival and functional status. Life expectancy was based on US life tables.

Methods used to derive estimates of effectiveness
No details of the method used to derive the clinical data were reported. The authors stated that, wherever possible, the most relevant and high-quality studies were selected. No details of the methods used to combine estimates from different primary studies were given.

Measure of benefits used in the economic analysis
The summary benefit measures used were the life-years (LYs) and quality-adjusted LYs (QALYs). Both benefit measures were estimated using the modelling approach. The health-related utility weights used to calculate the QALYs were derived from published studies and from the Pittsburgh study. However, little information on these sources of data was provided. Future benefits were discounted at an annual rate of 3%.

Direct costs
The viewpoint of the third-party payer was chosen. The cost categories included in the analysis were hospital stay for PMV or withdrawal, readmissions with and without ICU stay, post-hospital care (LTAC, SNF, or long-term nursing home with or without ventilator care, inpatient rehabilitation facility, or home care) and annual age-related costs. The unit costs and the quantities of resources used were not presented separately. The resource use data were based on published evidence, although details of resource consumption were not reported. The Pittsburgh cohort data were also used for some items. The costs were estimated using Medicare reimbursement rates. Discounting was relevant, as long-term costs were included in the analysis, and an annual rate of 3% was applied. The costs were updated to 2005 prices using the medical component of the Consumer Price Index.

Statistical analysis of costs
The costs and quantities were treated deterministically in the base-case analysis.

Indirect Costs
Productivity costs were not included in the analysis.

Currency
US dollars ($).

Sensitivity analysis
Both deterministic and probabilistic sensitivity analyses were carried out to address the issue of uncertainty surrounding some model inputs. A deterministic one-way sensitivity analysis was performed on individual data inputs, using ranges of values based on published sources or authors’ assumptions. A Monte Carlo simulation was undertaken by assigning probabilistic distributions to model inputs (uniform distributions to utilities and costs, beta distributions to probabilities). Variables of key interest that were investigated in depth (also by means of stratified analysis) were age, the probability of 1-year survival, and post-acute care discharge disposition. Finally, two alternative comparisons were also considered and were compared with ventilation withdrawal: mechanical ventilation for 4 days or more plus tracheostomy (alternative PMV); and mechanical ventilation for 2 to 7 days (short-term mechanical ventilation), which was compared with withdrawal by day 4, as in the Pittsburgh cohort.

Estimated benefits used in the economic analysis
In the base-case analysis, the expected LYs and QALYs were, respectively, 2.651 and 1.774 with PMV and 0.058 and 0.019 with withdrawal.

When alternative comparators were used, the expected LYs and QALYs were, respectively, 3.186 and 2.133 with the alternative PMV and 4.922 and 3.284 with short-term mechanical ventilation.
Cost results
In the base-case analysis, the expected costs were $196,077 with PMV and $52,269 with withdrawal.

When alternative comparators were used, the expected costs were $207,184 with the alternative PMV and $114,397 with short-term mechanical ventilation.

Synthesis of costs and benefits
Incremental cost-effectiveness and cost-utility ratios were calculated in order to combine the costs and benefits of the alternative strategies.

The incremental costs of PMV over withdrawal were $55,460 per LY gained and $82,411 per QALY gained.

The incremental costs of the alternative PMV over withdrawal were $49,525 per LY gained and $73,629 per QALY gained.

The incremental costs of short-term mechanical ventilation over withdrawal (by day 4, as in the Pittsburgh cohort) were $19,083 per LY gained and $28,517 per QALY gained.

The sensitivity analysis identified the most influential model inputs, such as cost of hospitalisation, readmission rate and 1-year mortality rates. Patient age was a key variable, the incremental cost per QALY gained with PMV compared with ventilation withdrawal being $14,289 for an 18-year-old patient, $127,859 for a 65-year-old patient, and over $206,000 for an 85-year-old patient. It was found that the incremental cost per QALY exceeded $100,000 at age 68 or more. Variations in other model inputs did not substantially alter the results of the base-case analysis, although the cost per QALY exceeded the threshold of $100,000 when 1-year mortality was greater than 50%.

Overall, the probabilistic sensitivity analysis showed that there was a 75% probability that the incremental cost per QALY gained with PMV compared with ventilation withdrawal was greater than $100,000.

Authors' conclusions
The authors concluded that the cost-effectiveness of prolonged mechanical ventilation (PMV) was highly dependent on patient age and the likelihood of poor short- and long-term outcomes. Specifically, the cost-effectiveness of PMV was less favourable as patient age approached the late 60s and the likelihood of short-term death increased beyond 50%.

CRD COMMENTARY - Selection of comparators
The authors provided a justification for the choice of the comparator, which was appropriately selected. Alternative strategies were also evaluated in the sensitivity analysis. You should decide whether they are valid comparators in your own setting.

Validity of estimate of measure of effectiveness
The clinical data may have been derived from papers that were selectively identified. The authors did not state whether a systematic review of the literature was carried out to identify potential sources, although they did state that only high-quality studies were selected. Only the characteristics of the Pittsburgh study were reported; no information on other sources of clinical data was provided. This limits the possibility of assessing the validity of the clinical inputs. The authors performed extensive sensitivity analyses in order to address the issue of uncertainty in these estimates.

Validity of estimate of measure of benefit
The use of QALYs and LYs as the summary benefit measures was appropriate. In particular, QALYs capture the impact of the diagnostic interventions on both quality of life and survival, which are relevant dimensions of health for critically ill patients. Some details of the sources of utility weights were reported, but the instruments used to elicit the utility weights were not described. Discounting was performed. Both LYs and QALYs can be compared with the benefits of other health care interventions.

Validity of estimate of costs
The analysis of the costs appears to have been consistent with the perspective of the analysis. The authors stated that physician costs were not included in the analysis, owing to difficulties in standardising acute and post-acute payments for physicians. Extensive details on the cost calculations were presented in an appendix to the paper. Statistical analyses of the costs were performed in the sensitivity analysis, in which variations in economic estimates was investigated in depth. The use of discounting was appropriate. The price year was reported, which enhances the possibility of replicating the analysis in other time periods.

Other issues
The authors reported the results from other studies involving similar interventions and patient populations so as to make meaningful comparisons. However, the results on the cost-effectiveness of mechanical ventilation were contrasting. The issue of the generalisability of the study results to other settings was not explicitly addressed, but the sensitivity analysis will have enhanced the external validity of the study results. The results of the base-case analysis and of the sensitivity analysis were satisfactorily reported. A tornado diagram showed the impact of the most relevant model inputs on the results of the analysis. The authors underlined the importance of considering the wishes of the patients and their families before withdrawing life-sustaining therapies, but they also remarked on the need for efficient strategies.

Implications of the study
The study results suggest that identification of patients likely to have unfavourable outcomes, lowering intensity of care for appropriate patients, and reducing readmission costs should be priorities in any attempt to improve the cost-effectiveness of PMV.

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