Patient characteristics and outcomes of a home mechanical ventilation program in a developing country

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ABSTRACT

Background: There are limited data on home mechanical ventilation (HMV) in developing countries. This study aimed to describe the patient characteristics, feasibility, and outcomes of an HMV program at a university hospital in Thailand.

Materials and Methods: Data were collected on all patients who were discharged with HMV between October 2014 and August 2015 at Thammasat University Hospital. Results: Twelve patients (eight men and four women) underwent HMV. They were aged 71.5 ± 17.6 years; mean ± standard deviation. Indications for HMV were 6 neurologic diseases (4 amyotrophic lateral sclerosis, 1 multiple system atrophy, and 1 stroke), 2 chronic obstructive pulmonary disease (COPD), 1 tracheomalacia, and 3 combined neurologic diseases and respiratory diseases (2 stroke and COPD, 1 stroke and tracheomalacia). The duration of follow-up was 799.5 ± 780.5 days. The ratio of family income to cost of HMV usage was 77.2:1 ± 5.5:1. All patients had tracheostomies. Modes of HMV were biphasic positive airway pressure (66.7%), pressure-controlled ventilation (16.7%), pressure-support ventilation (8.3%), and volume-controlled ventilation (8.3%). Complications occurred in ten patients (83.3%), including tracheobronchitis (20 events) and ventilator-associated pneumonia (12 events). Overall mortality was 41.7% (5/12 patients), including two patients who died due to ventilator-associated pneumonia. There were no instances of ventilator malfunction. Conclusions: HMV is feasible for patients with neurological diseases and COPD in a developing country. The relatively high rate of complications indicates the need for more comprehensive clinical services for chronic ventilator-dependent patients in this setting.

KEY WORDS: Chronic obstructive pulmonary disease, complication, developing country, mechanical ventilation, ventilator-associated pneumonia

INTRODUCTION

The prevalence of patients requiring prolonged mechanical ventilation (MV) leading to ventilator dependence has increased in recent years.1–4 There are various reasons causing prolonged MV, including systemic factors (e.g., comorbid diseases, organ failure, malnutrition), mechanical factors (e.g., critical illness, polyneuropathy, or myopathy), iatrogenic factors (e.g., inappropriate ventilator settings), complications of long-term hospital care (e.g., aspiration, infection), psychological factors (e.g., delirium, depression), and process of care factors (e.g., lack of weaning protocol, deficiency of staff training).5 Several consequences of ventilator dependence include excessive use of hospital resources (health-care personnel and health-care costs),
lack of opportunity for other critically ill patients to transfer to the intensive care unit (ICU), and higher risk of hospital-acquired conditions and ventilator-associated complications.[4,5] Consequently, discharge from hospital with home MV (HMV) is a reasonable consideration in these patients.

Common diseases requiring HMV are amyotrophic lateral sclerosis (ALS), spinal cord injury, muscular dystrophies, myotonic dystrophy, kyphoscoliosis, postpolio syndrome, central hypoventilation syndrome, obesity hypoventilation syndrome, and chronic obstructive pulmonary disease (COPD).[6] HMV can improve survival, especially for patients with ALS[7,8] and COPD,[9] as well as the quality of life.[10] Moreover, the combination of noninvasive HMV and cough-assist devices can reduce the tracheotomy rates in some patients with neuromuscular diseases and can also prolong survival.[11] However, there are still logistical issues surrounding HMV, including risk management, caregiver challenges, health insurance and reimbursement for the ventilator and essential equipment, patient-care costs, health-care team expenses for home visiting, and the referral system.[12-14] These issues regarding HMV are especially challenging in developing countries.

The aims of this study were to determine patient characteristics, outcomes, and feasibility of HMV usage in a country with a developing health-care system.

MATERIALS AND METHODS

Study population and design
Between October 2014 and August 2015, a descriptive observational study was conducted at Thammasat University Hospital, a 600-bed tertiary care teaching hospital in Bangkok, Thailand. All hospitalized patients requiring MV aged 18 or more years were identified by their use of a durable respiratory apparatus. Eligible patients were identified on one medical and three surgical ICUs, 1 cardiac care unit, 1 stroke unit, and 10 general medical or surgical wards. Following discharge, the research team visited each patient's home at least once to collect data on sex, age, reason for HMV, comorbid diseases, clinical features, mechanical ventilator and respiratory assist device characteristics, caregiver characteristics, ventilator, and patient-care costs, and morbidity and mortality outcomes. The health-care home visit was conducted by a nurse from a health promotion unit. Data were recorded using customized case record forms. Ethics approval was obtained from the Ethics Committee of the Faculty of Medicine, Thammasat University, Thailand. (IRB No. MTU-EC-IM-6-146/57).

Definitions
Prolonged MV was defined as the need of MV for 6 or more hours per day for 21 consecutive days.[13] In addition, ventilator dependence was defined as the failure to wean the patient from MV before hospital discharge.[15]

HMV was defined as MV used in the patient’s home with either tracheostomy (invasive) or facemask (noninvasive ventilation) regardless of hours of daily use. We excluded patients using HMV only for sleep-disordered breathing.[12]

Successful HMV weaning was defined as resolution of respiratory failure with liberation from HMV for 7 consecutive days.[13]

Death was classified as being due to the underlying disease or due to HMV complications such as respiratory tract infection or ventilator malfunction.

Statistical analysis
Descriptive statistics were analyzed using SPSS 16.0 for Windows (SPSS Inc., Chicago, IL, USA) and were presented as median ± standard deviation (SD) and range. Differences between groups were analyzed using the Chi-square test or the Fisher’s exact test for categorical data, and the Student’s t-test or the Mann–Whitney U-tests for continuous data. A two-sided P < 0.05 was considered statistically significant.

RESULTS

We identified 3606 hospitalized patients requiring MV during the 11-month study period based on the clinical records of Thammasat University Hospital. A total of 12 patients were discharged on HMV. Thus, the prevalence of HMV was 3.3/1000 ventilated patients. All of them used invasive HMV through a tracheostomy tube. Males numbered 8 (66.7%). The oldest patient was a 105-year-old woman with tracheomalacia. The most common reason for HMV was a neurologic disease (50.0%). Mean (SD) duration of HMV was 22.8 ± 2.8 h/day. The follow-up period for HMV usage was 799.5 ± 780.5 (20.0–2786.0) days. The time from onset of HMV to death was 949.4 ± 964.8 (161–2615) days. Ventilator costs were 204,333 ± 167,581 Thai baht (approximately 5676 ± 4655 US dollars). Home-care costs were 18,500 ± 13,866 Thai Baht (approximately 514 ± 385 US dollars). The ratio of family income to patient home-care cost was 7.2 ± 5.5 to 1 [Table 1].

The most common HMV complication was respiratory tract infection (83.3%), particularly tracheobronchitis. All-cause mortality rate of HMV patients was 5 of 12 (41.7%). Death due to respiratory tract infection occurred in two patients (40%). No patient died due to ventilator malfunction [Table 2].

One patient was successfully weaned from HMV after prolonged ventilator use for 1 year and 6 months. He was a 77-year-old male bedridden with COPD and stroke.

Bivariate analyses of risk factors for mortality in HMV patients found only one variable, the health-care
Table 1: Characteristics of home mechanical ventilation patients

| Characteristics                      | Total (n=12) |
|--------------------------------------|-------------|
| Men/women                           | 8 (66.7)/4 (33.3) |
| Age at initiation of HMV, years (range) | 71.5±17.6 (50-105) |
| Underlying causes of HMV            |             |
| Neurologic disease                  | 6 (50.0)    |
| ALS                                 | 4 (33.3)    |
| Multiple system atrophy             | 1 (8.3)     |
| Stroke                              | 1 (8.3)     |
| Respiratory disease                 | 3 (25.0)    |
| COPD                                | 2 (16.6)    |
| Tracheomalacia                      | 1 (8.3)     |
| Neurologic and respiratory disease  | 3 (25.0)    |
| Stroke and COPD                     | 2 (16.6)    |
| Stroke and tracheomalacia           | 1 (8.3)     |
| **HMV mode**                        |             |
| Biphasic positive airway pressure ventilation | 8 (66.7)    |
| Pressure-controlled ventilation      | 2 (16.7)    |
| Pressure-support ventilation         | 1 (8.3)     |
| Volume-controlled ventilation        | 1 (8.3)     |
| **Alarm setting existing in ventilator** | 10 (83.3)  |
| Duration of HMV/day, hours (range)  | 22.8±2.8 (16.0-24.0) |
| Duration of follow-up, days (range) | 799.5±780.5 (20.0-2786.0) |
| Time from home to hospital, minutes (range) | 35.0±21.5 (10-90) |
| **Health-care home visit, events**  | 5 (41.7)    |
| Complementary equipment             |             |
| Oxygen tank or concentrator         | 10 (83.3)   |
| Sputum suctioning machine           | 12 (100)    |
| Nebulized machine                   | 6 (50)      |
| Pulse oximeter                      | 10 (83.3)   |
| Self-inflating bag                  | 10 (83.3)   |
| Cuff pressure manometer             | 1 (8.3)     |
| Number of caregivers per patient    | 1.8±0.6     |
| **Number of well-trained caregivers** | 9 (75.0)   |
| **Income: costs ratio (range)**     | 7.2:1±5.5:1 (1.7:1-20.0:1) |

aData are n (%), mean±SD unless otherwise stated. HMV: Home mechanical ventilation, SD: Standard deviation, COPD: Chronic obstructive pulmonary disease, ALS: Amyotrophic lateral sclerosis

Table 2: Outcomes of home mechanical ventilation usage

| Outcomes                          | Total (n=12) |
|-----------------------------------|-------------|
| HMV complications                  | 10 (83.3)   |
| Tracheobronchitis, events         | 20          |
| Ventilator-associated pneumonia, events | 12          |
| Loose tracheostomy, events        | 17          |
| Granulation-tissue formation at tracheostomy, events | 2          |
| Pneumothorax, events              | 1           |
| Ventilator malfunction, events    | 1           |
| Consequence of HMV complications, events |             |
| Emergency department visit due to ventilator malfunction | 1          |
| Emergency department visit due to other complications | 24         |
| **Hospitalization**               | 17          |
| **Died**                          | 5 (41.7)    |
| **Cause of death**                |             |
| **Underlying disease**            | 3 (25.0)    |
| **HMV complications**             | 2 (16.6)    |
| **Ventilator malfunction**        | 0 (0)       |

aData are n (%), mean±SD unless otherwise stated. HMV: Home mechanical ventilation, SD: Standard deviation

DISCUSSION

In our survey of HMV in a developing health-care system, we found only one strategy, the health-care home visit that significantly improved survival. This understanding might be a guideline to assist physicians in the medical practice for HMV patient in similar situations.

The management of patients requiring HMV requires careful assessment and preparation, including education of caregivers and family members, evaluation of financial issues, and coordination of the home health-care team.[12,13,16] Our study did not find that financial issues were a problem in the limited sample population. In addition, reimbursement issues for HMV in our country Thailand were that an HMV patient could reimburse cost of home mechanical ventilator by maximally 20,000 Thai Baht (approximately 555 US dollars) when he or she has health insurance under the government or state enterprise officer scheme, however, other medical plans do not cover this cost. On the contrary, the national health program in the United States, Medicare, will cover rental reimbursement for medically necessary durable medical equipment including ventilators and respiratory assist devices.[17]

The advantages of HMV were discovered including releasing hospital ICU beds for other acutely ill patients, reducing exposure to hospital-acquired infections,[18] decreasing hospital stay, reducing hospital costs,[16,19] increasing survival, particularly in patients with ALS having MV through tracheostomy,[20] increasing quality of life,[21,22] and maximizing integration into the community[22] as well as enhancing relationships between family members and patient.[17]

A large survey study of 16 European countries, in these developed countries, found that the estimated prevalence of HMV in Europe was 6.6/100,000 people,[23] A study from Australia and New Zealand found the prevalence of HMV use was 9.9 and 12 patients/100,000 population in 2013, respectively.[24] The common indications for their HMV were obesity hypoventilation syndrome (31%), neuromuscular diseases (30%), and COPD (8%).[24] In the United States, the prevalence of HMV use increased from 2.8 patients/100,000 in 1987 to 7.1 patients/100,000 in 2006. Neuromuscular disease was the most common reason for HMV (69%) followed by COPD (23%).[22]

In Turkey, a study of children found a rapid increase in HMV usage from 2001 to 2006. The common indication for HMV was chronic respiratory failure, especially chronic lung disease (61.8%).[11] In addition, a study from a children’s hospital in Serbia found an increasing prevalence of HMV (29 children) between 2001 and 2011. Neuromuscular disease was the most common indication (62.1%). One-fourth of these patients died due to other causes without ventilator malfunction.[25]
Table 3: Risk factors for mortality in home mechanical ventilation patients

| Variables                          | Alive (n=7) | Dead (n=5) | P*  |
|------------------------------------|-------------|------------|-----|
| Male/female                        | 5/2         | 3/2        | 1.00|
| Age (years)                        | 68.1±13.3   | 76.2±23.3  | 0.46|
| Underlying neurologic disease      | 4 (57.1)    | 2 (40.0)   | 0.60|
| Duration of HMV/day (hours)        | 22.9±3.0    | 22.8±2.7   | 0.97|
| Existence of self-inflating bag    | 5 (71.4)    | 5 (100)    | 0.47|
| Number of caregiver ≥ 2 persons    | 2 (40.0)    | 6 (85.7)   | 0.22|
| Well-trained caregiver             | 6 (85.7)    | 3 (60.0)   | 0.52|
| Time from home to hospital, minutes| 34.3±26.4   | 36.0±15.2  | 0.90|
| Health-care home visit, events     | 5 (71.4)    | 0 (0)      | 0.028|
| Income: costs ratio                | 8.1±1.6±6.3:1| 5.9±1±4.6:1| 0.53|
| HMV complications                  | 6 (85.7)    | 4 (80.0)   | 1.0  |

*Data are n (%), mean±SD unless otherwise stated. Comparision between surviving group and dead group. HMV: Home mechanical ventilation, SD: Standard deviation.

To the best of our knowledge, our study is the first feasibility study of HMV for adult patients in a developing country in Asia. The prevalence of HMV was more than 3/1,000 ventilated patients. In keeping with usual clinical practice, ALS, and COPD were the common indications for HMV use, similar to those in developed countries. Although HMV use was associated with higher complication rates (83%) and death (16%), no patient died due to ventilator malfunction, which is similar to the findings of a large study from the United Kingdom. The authors believe that it should be possible to minimize HMV complications with a good risk prevention strategy. Moreover, the costs of patient care, the mechanical ventilator, and respiratory assist devices were acceptable expenses in our study.

At present, Thammasat University Hospital has no specialized unit and also no respiratory therapist for the prolonged ventilator weaning or a holistic health-care team for long-term HMV care. Most of our ventilated patients required ICU admission for prolonged weaning from MV lead to increasing the utilization of health-care resources and reducing opportunities for other critically ill patients to transfer to the ICU.

One of the limitations was the small sample size, which may be a constraint for the detection of other significant and independent factors for mortality or morbidity outcomes. In addition, we did not collect respiratory parameters such as tidal volume, minute ventilation, arterial blood gases, which might have affected patient outcomes. Furthermore, the broader family and social impacts were not captured in terms of quality of life for the caregivers or family members.

CONCLUSIONS

Although significant complications have been observed in our study, HMV is feasible in a developing country and can potentially reduce health-care expenditure. A comprehensive HMV service with provision of home visits should be setup for prolonged ventilator-dependent patients in this setting.

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Conflicts of interest

There are no conflicts of interest.

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