1-year survival predictors for patients using home mechanical ventilation

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Abstract—

Introduction: The usage of home mechanical ventilation (HMV) either invasive or non-invasive has been used in patients with several diseases such as ALS, CHS…. Several variables can have an effect on the survival and predict the outcome within a period of 1 year after the administration of HMV.**Objective:** The aim of this study is to measure the 1-year survival for patients using (not)-invasive home mechanical ventilation and to measure the predictors of the survival within 1 year after administration of HMV. **Methods**: A retrospective observational cohort study was done in the period between (01-06-1984-31-12-2014) to all patients who used HMV in Maastricht center of home mechanical ventilation (MaCHo) in The Netherlands. Data of the patients was collected from the SAP system of Maastricht University Hospital.**Results:** 1080 patients were eligible for analysis, 660 men (61, 1%), 420 women (38, 8%). Mean age was 62 (19-92) years old. 875 patients have survived during the first year of using HMV. We discovered that several factors can be used as a predictors for the survival. Patients with rapid progress neuromuscular disorders have the lowest survival rate within one year of using HMV with 113 patients (55, 1%) died. COPD and lung diseases have the 2nd lowest survival rate with 46 patients (22,4%) died. Patients with OSAS/CSAS/OHS have the best survival rate among the groups with 308 patients (35,2%) survived the 1st year after using HMV. Patients with slowly progress neuromuscular diseases have a higher survival rate with 193 patients (22,1%), Myotonic dystrophy patients have higher survival rate with 95 patients (10, 9%). Other predictors for mortality were: the age of patients at starting their HMV (p-value=0,034), odds ratio (1,022), HCO3 (p-value=0,011), odds ratio (1,066), and the predicted FVC %(p-value=0,087), odds ratio (0,990).**Conclusion:** In a total of 1080 patients were included in the study, 875 patients were survived the first year of using HMV, on another hand, and 205 patients were deceased. Age at the start of using HMV, HCO3, FVC predicted, and underlying diseases are predictors of the survival within the first year of using home mechanical ventilation.

Index Terms— Home mechanical ventilation, survival, predictors, blood gases, diagnosis, lung functions, adults

1 INTRODUCTION

The usage of home mechanical ventilation (HMV) either invasive or non-invasive has been employed in patients with several diseases such as ALS, CHS, COPD, Duchenne muscular dystrophy, kyphoscoliosis, myotonic dystrophy, OHS, spinal cord injury, post-polio syndrome, and other muscular dystrophies and myopathies. Two types of home mechanical ventilation can be used in those patients, non-invasive ventilation (NIV); refers to the administration of ventilator support without using an invasive artificial airway such as endotracheal tube or tracheostomy, such as facemasks. This type of ventilation has markedly increased in the past two decades, and it's very flexible in the management of people with acute or chronic respiratory failure [(1)]. Patients with hypercapnic forms of acute respiratory failure are most likely to benefit from NIV [(2)]. Indications of installing home mechanical ventilation are patients with acute exacerbation of COPD, acute or chronic hypercapnic respiratory failure due to chest wall deformity or neuromuscular diseases, obstructive/central sleep apnea, parenchymal lung diseases, spinal cord injuries. Current evidence about the therapeutic benefit of HMV is consistent, producing the alleviation of the symptoms of chronic hypoventilation. As a consequence, HMV improves health-related quality of life (HRQL) in patients with chronic hypoventilation; this effect is maintained over time and is influenced by the progression of the disease among other factors [(3)]. Long-term survival is improved in most patient groups, even though the long-term prognosis is often severely limited [(4)]. There is conclusive evidence that noninvasive ventilation can prolong survival and improve the quality of life in many chest wall and neuromuscular diseases. In other situations, it

can palliate symptoms of nocturnal hypoventilation and breathlessness. In stable chronic obstructive pulmonary disease patients, firm evidence is lacking, although specific subgroups may benefit [5]. There is evidence that non-invasive positive pressure ventilation uses as treatment for a severe stable chronic obstructive pulmonary disease which can improve survival and reduce hypercapnia. Moreover, several studies explained the benefits of using home mechanical ventilation in patient with obese hypoventilation syndrome (with/without OSAHS), they have concluded that the use of HMV is an effective treatment for the correction of blood gasses as well as functional alteration and achieving prolongation of survival rates [7]

Several studies showed that by far patients with ALS have the poorest survival rate within five years. On other hand, patients with scoliosis, polio, and Pickwick presented the best survival rate. Moreover, negative predictors of survival were age, tracheostomy ventilation [8]. One study mentioned that Patients with kyphoscoliosis treated with HMV experienced better survival rate in comparison with using long-term oxygen therapy alone, even with adjusting for age, gender, and blood gas levels [9]. The indication of pursuing NPPV is still controversial, Patients with OHS, NM, and KYPH had the highest probability of continuing NPPV, while patients with COPD had the lowest values [10].

The aim in this study is to measure the 1-year survival for patients using (not)-invasive home mechanical ventilation and to measure the predictors of the outcome.

Materials and method

A retrospective observational cohort study was done between the periods (01-06-1984-31-12-2014) of the patients who used HMV. Data of the patients was collected from the SAP system (version 23) of Maastricht University Hospital, Maastricht, The Netherlands, as well as from Maastricht center of home mechanical ventilation (MaCHo). The following variables have been used in the SPSS program to collect the date from the patients: patient's survival and death within one year, age, age at starting of HMV, gender, diagnosis, type of ventilation, arterial/capillary blood gasses and lung functions (FVC in liter and predicted) before using HMV in a maximum period of six months, Have the patients stopped using HMV or not , and the reason and date of stopping if applicable.

Inclusion criteria: patients over the age of 18 at starting of HMV, patients who started HMV between the periods of (01-06-1984-31-12-2014). Exclusion criteria: the patients who started HMV after 31-12-2014. The number of patients who included in the study were overall 1080 patients.

Patient selection

1273 patients who assigned for starting home mechanical ventilation, we have excluded 60 patients because their age was less than 18 when they started using home mechanical ventilation, and we have excluded 133 patients because they started their home mechanical ventilation after the date of 31/12/2014. Overall of 1080n patients were included in the study (figure1).

Figure1: Flowchart of the patients selected

Patients were divided into two groups (Survived one year of using HMV, n=875) and (died within one year of using HMV, n=205). Then we investigated their diagnosis, blood gasses, lung functions, and then we observed the predictors of the

outcome at the end.

Statistical analysis

All tables and figures will be processed as images. You need to embed the images in the paper itself. Please don't send the images as separate files we have used two tests to indicate which variables is normality or non-normality distributed. These tests were Kolmogorov-Smirnov and Shapiro-Wilk tests. All variables, which appeared, they are normality distributed; we have used Chi-square and t-tests, on other hand, Mann-Whitney test was used for the non-normality distributed variables in order to abstract the Univariate analysis. However, we have included all the significant (p-value<0, 05) variables and used them as predictors for survival. Moreover, we have chosen all these predictors and add them in a binary logistic regression analysis in order to get the Multivariate analysis for the survival predictors. However, the result for the normality-distributed variables was observed as mean SD, whereas the non-normality distributed variables were observed as median. Moreover, the survival analysis was done by using Kaplan-Meier test and Cum survival. We have coded the patients regarding their diagnosis into a diagnosis code; we have divided the patient into five main diagnosis group/classifications. These classifications are the followings: 1/Obstructive sleep apnea syndrome (OSAS)-Central sleep apnea syndrome (CSAS)-Obese hypoventilation syndrome (OHS), 2/Rapidly progress neuromuscular/thorax diseases, 3/Slowly progress neuromuscular/thorax diseases, 4/Myotonic dystrophy, 5/COPD and lung diseases.

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Result

In table1, patient's characteristics, blood gasses, and lung function tests are shown. The patients were divided into two main groups according to their survival. In a total of 1080 patients were included in the study, 875 patients were survived the first year of using HMV, on another hand, and 205 patients were deceased. No difference in gender was observed between the groups. Age at start of HMV between groups differs, with survived patients started HMV younger than the other group. The current age of the patients do not show any different between the groups, median age of all patients was 62 (19-92) years old, and 660 patients (61, 1%) were males. The ventilation type (invasive/not-invasive) showed a difference between the groups with 997 patients (92, 3%) who used non-invasive ventilation and 83 patients (7, 7%) who used an invasive ventilation. Patients who used non-invasive ventilation survived the one year with 805 patients (91,7%) comparing with the group who died within one year of 192 patients (93,7%). On other hand, patients who used invasive ventilation survived the one year with 72 patients (8,2%) comparing with the group who died within one year of 11 patients (5,4%). Overall, patients had a mild FVC in liters 2,12(1,52-3,18) and predicted FVC 63,40±25,5. Patients who survived the one year of using HMV had a higher FVC in liters and predicted FVC with 2,22(1,54-3,37), 65,1 ± 24,5, respectively, compared to the patients who died within one year after using HMV with FVC in liters and predicted FVC of 2,02 (1,4-2,56), 55,85±19,2, respectively. Blood gasses analysis of all patients is shown In table1. All patients have a normal PH of 7,40 (7,37-7,73), slightly high Pco2 of 6,20 (5,40-7,30), high act.Bicarbonate of 29,3 ±5,04, and a high base excess of 3,77±4,29. Patients who survived had the lowest PH 7,40 (7,37-7,43), Paco2 6,1 (5,4-7,3), act.Bicarbonate 28,9±4,86, and base excess 3,46±4,17, as compared to the other group.

Table1: Patient's characteristics according patient's survival

Varaibles	All (n=1080)	Survived (n=875)	Died(n=205)	P-value
Gender				NS
Male (n)	660 (61,1%)	538 (61,5%)	122 (59,5%)	
Female (n)	420 (38,8%)	337 (38,5%)	83 (40,5%)	
Age at start_HMV	57,85 (18-91)	56.86 (18-85)	62,08 (19-91)	0,000
Age	62,28 (19-92)	62,1 (19-89)	62,73 (19-92)	NS
Ventilation type				0,043
Non-invasive	997 (92,3%)	805 (91,7%)	192 (93,7%)	
Invasive	83 (7,7%)	72 (8,2%)	11 (5,4%)	
FVC_in_liters (L)*	2,12(1,52-3,18)	2.22 (1.54-3.37)	2.02 (1.4-2.56)	0,001
FVC_pred%**	63,40 ± 25,5	65,1 ±26,5	55.85 ±19,2	0,000
Variables	All (n=1080)	Survived (n=875)	Died(n=205)	P-value
PH*	7,40 (7,37-7,73)	7,4 (7,37-7,43)	7,41 (7,38-7,44)	0,034
Paco2 (kPa)*	6,20 (5,40-7,30)	6,1 (5,4-7,3)	6,4(5,6-7,6)	0,010
Act.Hco3**	29.3±5,04	28,9±4,86	30,5±5,50	0,001
BE**	3,77±4,29	3,46±4,17	5,09±4,56	0,000

*Median (interquartile range), **mean± SD. FVC= Forced vital capacity.

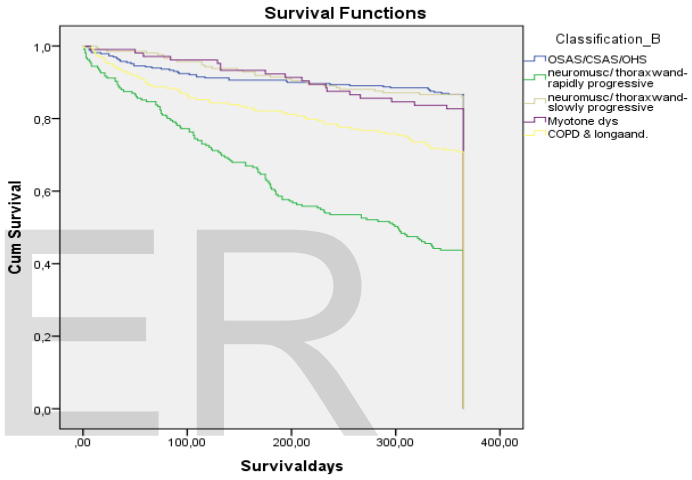
Table2 illustrates the relation between the underlying diseases and the 1-year survival of patients using HMV. Patients with rapidly progressing neuromuscular/thorax diseases have the lowest survival rate within one year of using HMV with 113 patients (55,1%) died, compared with 102 patients (11,7%) survived. COPD and lung diseases have the 2nd lowest survival rate with 46 patients (22,4%) died, compared with 177 (20,2%) survived. Patients with OSAS/CSAS/OHS have the best survival rate among the groups with 308 patients (35,2%) survived the 1st year after using HMV. Moreover, patients with slowly progressing neuromuscular/thorax diseases have a higher survival rate with 193 patients (22,1%), compared with 16 patients (7,8%) died. Myotonic dystrophy patients have higher survival rate with 95 patients (10,9%), compared to 9 patients (4,4%) died. Kaplan-Meier curves of diagnosis cause mortality at one year of using home mechanical ventilation are shown in figure2.

Tabl2: Survival table according to patient's diagnosis

Variables	All (n=1080)	Survival (n=875)	Died(n=205)	P-value	Odd ratio
OSAS/CSAS/OHS	329	308 (35,2%)	21 (10,2%)	0,000	3,81
Neuromuscular/thorax-rapidly progress diseases	215	102 (11,7%)	113 (55,1%)	0,000	0,23
Neuromuscular/thorax-slowly progress diseases	209	193 (22,1%)	16 (7,8%)	0,000	3,1
Myotonic dystrophy	104	95 (10,9%)	9 (4,4%)	0,000	2,74
COPD and lung diseases	223	177 (20,2%)	46 (22,4%)	0,000	-

OSAS=Obstructive sleep apnea syndrome, CSAS=Central sleep apnea syndrome, OHS=obesity hypoventilation syndrome

Fig2: Kaplan-Meier curve for 1-year survival



The univariate analysis of variables related to 1-year survival are: Age at start of HMV (p-value=0,000), ventilation type (p-value=0,043), FVC in liter (p-value=0,001), predicted FVC (p-value=0,000), PH (p-value=0,034) PaCO2 (p-value=0,010), Act.HCO3 (p-value=0,001), ,BE (p-value=0,000), and the underlying diseases. For the multivariate analysis (table3) we have included all these variables in a binary logistic regression analysis. We have found that Age at start of using HMV (p-value=0,034), HCO3 (p-value=0,011), predicted FVC (0,087), and the underlying diagnosis are predictors for the survival. We have used OSAS/CSAS/OHS group as a reference to the other underlying diseases.

DISCUSSION

Home mechanical ventilation is increasingly used as a treatment for patients with several diseases, such as respiratory, neuromuscular diseases, chest wall deformities, and sleep diseases. It is important for the patients to know and evaluate the benefits of using home mechanical ventilation and to expect the prognosis. In our study, we have measured the predictors of survival during one year period for patients using either invasive or non-invasive home mechanical ventilation. We have collected the patients retrospectively from medical files and electronic patient records from the SAP system of Maastricht University Hospital, Maastricht, The Netherlands. We have found that the age at starting home mechanical ventilation (p-value=<0, 05), odds ratio (1,022), HCO3 (p-value=0,011), odds ratio (1,066), predicted FVC (p-value=0,087), odds ratio (0,990), and the underlying diseases are the most predictors for survival 1-year in patients using home mechanical ventilation. We found that patients with rapidly progress neuromuscular disorders (p-value=0,000), odds ratio (12,127) had the lowest survival rate after using HMV in 1 year period. On another hand, OSAS/CSAS/OHS group have the highest survival rate after using HMV in 1 year period. However, we have noticed that some blood gasses including PH, PCO2, and BE having no significant effect on one-year survival but HCO3 indeed is a predictor for the survival. One of the last studies indicated 110 chest wall disease patients were assigned in a study to evaluate the predictors of mortality who were treated with noninvasive home mechanical ventilation, their results suggested that PACO2 levels>50mmhg at one month after starting HMV as well as the presence of comorbid condition are risk factors for mortality of these patients [(11)]. This study is reasonable due to the fact they calculate the comorbidities of their patients, which wouldn't happen in our case. In an early study in 2006[(12)], 1526 patients were reported prospectively for ten years to assess their survival rate; they have found that the poorest survival rate was in patients with ALS with only 5% alive after five years. The result of this study is nearly similar to the finding we have, but in our study, we have measured all rapid progress neuromuscular diseases patients who have shown the lowest survival rate within one year of using HMV with 113 patients (55,1%) died, compared with 102 patients (11,7%) survived. Moreover, in one study published in 1996 [(13)], measured the predictors of survival in patients receiving domiciliary oxygen therapy or mechanical ventilation in 10 year period. They have found that survival is slightly better for patients with Asthma and bronchiectasis, but patients with neuromuscular diseases have the longest survival with 6.5 years, which is significantly different from other articles which shown that patients with neuromuscular diseases have the lowest survival outcomes. However, similar to other reports, patients with COPD/lung diseases have the highest values of PCO2, HCO3, and bases excess with 7.75±1.87, 32.7±5.71, 6.83±5.17, respectively. Moreover, similar to other studies, we have found that patients with OHS. Slowly progress neuromuscular diseases had the highest probabilities of pursuing HMV, while patients with COPD have the lowest values [(14)]. Seneff et al. [(15)] identified age 65 years and older as having a significant association with 1-year mortality in patients admitted to healthcare unit due to acute exacerbation of COPD. In our study, we have found that patient's age at starting their home mechanical ventilation is a significant predictor of survival with median 56.86 years old (18-85) survived, and median 62, 08 years old (19-91) died in the 1st year of using HMV. The mortality rate of COPD and lung diseases patients within one year is 22,4% which is relatively low compared to another article investigate the long-term survival for COPD patients receiving non-invasive ventilation in acute lung failure [(16)], the 30-days mortality rate of patients using NIV was 29,3%. We believe our study has some limitations include lack of blood gas values and lung functions, comorbidities. We think that these restrictions have a significant effect on the results, and more investigation should be undertaken to measure the predictors of the outcome.

Acknowledgments

Both patients gave informed consent for publication of data and images regarding this case report. Abdulrahman Issa and Roy Sprooten conceived and drafted this article. All co-authors critically revised the article and gave final approval of this version to be published.

Conclusion

The goal of this study is to measure the survival of patients using home mechanical ventilation within one year and to evaluate the predictors of survival. In a total of 1080 patients were included in the study, 875 patients were survived the first year of using HMV, on another hand, and 205 patients were deceased. From this vast patients population that recorded retrospectively, we have found that several predictors for the survival. Age at start of HMV, HCO3, and predicted FVC were the most predictors for survival in patients using HMV for one year. The use of HMV is associated with a lower mortality rate Patients suffering from rapid progress neuromuscular diseases at all times clearly had the highest probabilities to die within one year of starting home mechanical ventilation. While OSAS/CSAS/OHS group had the lowest chances to die within one year of starting HMV. Among the remaining patient groups, differences in mortality would be difficult to point out and presents a more uniform pattern. The existing evidence indicates that HMV is useful in the majority of OSAS/CSAS/OHS patients and results in significant improvement in symptoms of somnolence, dyspnea, edema, and sleep quality, as well as improvements in gas exchange, sleep architecture, and HRQoL. On another hand, HRQL was more impaired in COPD patients [17]. PINTO et al. [18] have shown that the relation between using of NPPV in patients with ALS and quality of life, unfortunately, NPPV didn't improve their HRQol.

Limitations: We believe this study has some limitations include the lack of available data such as lung and blood gasses tests, comorbidities, and the diagnosis accuracy. Further research is needed. The strengths are this study conducted in a large population and the accurate of mortality status.

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