Telemonitoring in Home Mechanical Ventilation

Katia Vanessa Cantarini[1], Rosineide Pereira Sanches[1],
Vanessa Vieira Donini[1], Ruy Pires[2], Heloisa Amaral Gaspar[1]

TO THE EDITOR,

A recent Brazilian survey has shown that, within a year, approximately 300,000 patients undergo home care treatment, and 6% of these patients require ventilatory support (bi-level or life-support ventilators). Importantly, home care treatment has increased by 15-20% on a yearly basis.[1,2]

Despite the increasing demand for home mechanical ventilation (HMV), there are still several barriers to discharging these patients, including operational logistics, keeping the patient safe and clinically stable in a home environment, staff work overload, clinical knowledge for optimizing the ventilation pattern according to the patient's needs, etc.[3] All these factors, in addition to the lack of an evidence-based standard of care, make treating patients on HMV a challenging task.[4]

Telemonitoring patients on HMV may reduce emergency room visits and inpatient admissions and is associated with improved patient management and outcomes, as well as cost savings. The additional possibility of predicting respiratory exacerbation makes telemonitoring a potential tool to revolutionize home-assisted ventilation care.[5]

Home Doctor is one of the largest home care companies in Brazil and provides health care for more than 5,500 patients per year, 10% of whom require ventilatory support. In 2021, the company started an HMV patient-telemonitoring program and, considering the paucity of Brazilian data regarding this topic, we aimed to report the preliminary outcomes of our first 34 patients. From April 2021 to March 2022, we conveniently selected 34 patients on HMV to be enrolled in our telemonitoring program. All patients provided written consent upon enrollment. Physiotherapy management was administered according to current home care protocols and consisted of 40-45 min sessions. Patients received physiotherapy sessions according to their clinical condition, and extra daily visits were provided if clinical worsening was detected. The mean age of the patients was 33.4 years (0-91 years), the predominant sex was female (62%), and the most prevalent diagnosis was neurological/neuromuscular disease (59%). Of all patients, 82% received invasive mechanical ventilation. Nocturnal ventilation was used in 41% of the patients, and continuous ventilation (24 h/day) in 59% (Table 1).

All ventilators (Stellar® and Astral®, ResMed, Sydney, Australia) were coupled to a modem to transmit ventilatory data to the cloud (Airview®) on a daily or on-demand basis. The ventilator parameters and settings (median and interquartile range values per day or minute-by-minute values) could be assessed on a detailed sheet. All alarm activations could also be monitored. Briefly, a clinical physical therapist analyzed the data for each patient 3 times per week and provided the clinical staff with insights during a routine weekly meeting. Any action to be taken was addressed to the attending physical therapist responsible for the patient. Resolution (or not) of the action was discussed in the following meeting. Basically, the topics evaluated in each patient were: HMV settings, compliance (daily hours of use), leakage, tidal volume, respiratory rate, and percentage of spontaneous triggering. The most frequently activated ventilator alarms for each patient were also assessed.

The interventions resulting from monitoring were categorized into: 1) adjustments related to ventilatory support when problems with cuff insufflation, mask fixation, aspiration frequency, or inhalation support were identified; 2) optimization of ventilation parameters, such as inspiratory or expiratory pressure, respiratory frequency, triggering, and tidal volume; 3) alarm adjustments; 4) identification of early clinical deterioration; 5) equipment adjustments (upgrade or downgrade); 6) visualization of equipment manipulation by family members without authorization, and 7) oxygen therapy adjustments (Table 1).

Additionally, a 3-month pre- and post-telemonitoring (pre-TM vs. post-TM) evaluation period of the same 34 patients revealed reductions in extra clinical visits for managing mechanical ventilation (pre-TM = 5; post-TM = 2) and in device problems or malfunctions that required equipment change (pre-TM = 3; post-TM = 2). Although these results are encouraging, one should note that even before telemonitoring, events were rare. Moreover, the descriptive nature of the present study and the absence of a pre/post statistical analysis must be considered.

The efficacy of HMV is dependent on optimal ventilatory support (suitable settings and leak management) to minimize side effects. Thus, ventilator data download functions can be used to assist in clinicians' decision-making to enable the optimal delivery of HMV.[6] Our preliminary results are in line with that. In fact, almost 50% of the analyzed patients were provided optimizations of the HMV settings, be they optimizations of ventilator parameters, leak control, tidal volume, trigger adjustment, or alarm settings. More importantly, we found that caregivers/family members were changing the ventilation parameters without clinician consent in two cases, a fact that could have risked the patients' lives. In another case, an important leak due to cuff inflation system damage was identified, which led to tracheostomy tube replacement.

1. Home Doctor, Brasil.
2. ResMed, São Paulo (SP), Brasil.

Table 1. Diagnosis, MV profile, and outcomes of telemonitoring.

Diagnosis	Total patients (%)	IMV (%)	NIV (%)
Neurological Disease	21 (62)	18 (86)	3 (14)
Hypoxic-ischemic encephalopathy	5 (24)	4 (80)	1 (20)
Amyotrophic Lateral Sclerosis	5 (24)	4 (80)	1 (20)
Stroke	4 (19)	4 (100)	0
Spinal Muscular Atrophy type 1	2 (9.5)	2 (100)	0
Muscular Dystrophy	1 (4.7)	1 (100)	0
Brown-Vialetto-Van Laere Syndrome	1 (4.7)	1 (100)	0
Lennox-Gastaut Syndrome	1 (4.7)	1 (100)	0
Mitochondrial encephalomyopathy	1 (4.7)	1 (100)	0
Guillain-Barre Syndrome	1 (4.7)	0	1 (100)
Genetic Disease	8 (23)	5 (62.5)	3 (37.5)
Arnold-Chiari Syndrome	2 (25)	0	2 (100)
Genetic Disorder (under investigation)	1 (12.5)	1 (100)	0
Down Syndrome	1 (12.5)	1 (100)	0
Edwards Syndrome	1 (12.5)	1 (100)	0
Patau Syndrome	1 (12.5)	1 (100)	0
Krabbe Syndrome	1 (12.5)	1 (100)	0
Williams Syndrome	1 (12.5)	0	1 (100)
Osteomuscular disorders	2 (6)	2 (100)	0
Achondroplasia	2	2 (100)	0
Respiratory disease	2 (6)	1 (50)	1 (50)
COPD	1 (50)	0	1 (100)
Bronchopulmonary dysplasia	1 (50)	1 (100)	0
Heart disease	1 (3)	1 (100)	0
Congenital heart disease	1 (100)	1 (100)	0
MV Profile & Outcomes			
HMV duration			
Years (mean ± SD)	5.6 ± 5.3	5.7± 5.7	5.4± 3.6
Ventilatory Support			
Daily hours of use (mean ± SD)	19 ± 7	21 ± 6	10 ± 6
Adjustments related to ventilatory support	19 (56)	12 (63)	7 (37)
Daily hours of use	6 (32)	4 (67)	2 (33)
Headgear	5 (26)	0	5 (100)
Inhalation therapy	4 (21)	4 (100)	0
Cuff	2 (10.5)	2 (100)	0
Clearance of secretions	2 (10.5)	2 (100)	0
Ventilation optimization	16 (47)	11 (69)	5 (31)
Mode	1 (6)	1 (100)	0
Parameters	15 (94)	10 (67)	5 (33)
Alarm adjustments	7 (21)	5 (71)	2 (29)
Identification of early clinical deterioration	5 (15)	4 (80)	1 (20)
Equipment adjustments	4 (12)	3 (75)	1 (25)
Upgrade	2 (50)	1 (50)	1 (50)
Downgrade	2 (50)	2 (100)	0
Equipment manipulation by family members	2 (6)	1 (50)	1(50)
Oxygen therapy adjustments	1 (3)	1 (100)	0

COPD: Chronic Obstructive Pulmonary Disease; IMV: Invasive Mechanical Ventilation; NIV: Non-invasive Ventilation.

Remote ventilator data analysis also improved operational logistics. Some clinical visits were unnecessary or were more assertive because of the knowledge and data obtained from telemonitoring. Usually, extra visits were related to alarm fatigue in the absence of an attending clinician. In one patient on noninvasive ventilation, alarm excess due to an important leak was observed during nighttime periods but not reported during the clinician's regular daytime visits and was responsible for affecting the sleep quality of the patient and his family. This leak was also responsible for a worsening of the ventilation pattern. The problem was solved after changing the

patient's headgear, which led to an improvement in patient and family sleep quality. Additionally, after the leak was resolved and ventilatory support was adjusted, oxygen support could be suspended. Telemonitoring promoted a feeling of enhanced well-being and safety.

In conclusion, our 1-year preliminary analysis showed that the telemonitoring of patients on HMV was associated with earlier ventilation optimization and improved clinical management, as well as more assertive operational and logistical management.

AUTHOR CONTRIBUTIONS

All authors contributed equally in the investigation, analyses, and writing and approval of the published manuscript.

REFERENCES

1. Censo NEAD-FIPE de Atenção Domiciliar [homepage on the Internet]. São Paulo; 2020 [cited 2022 Mar 15]. Available from: https://www.neadsaude.org.br/wp-content/themes/nead/nead-digital/Censo-NEAD-FIPE-2019-2020/index.html.
2. Carnaúba CMD, Silva TDA, Viana JF, Alves JBN, Andrade NL, Trindade EM. Clinical and epidemiological characterization of patients receiving home care in the city of Maceió, in the state of Alagoas, Brazil. Rev Bras Geriatr Gerontol. 2017;20(3):352-362. https://doi.org/10.1590/1981-22562017020.160163.
3. Yang L, Nonoyama M, Pizzuti R, Bwititi P, John G. Home mechanical ventilation: A retrospective review of safety incidents using the World Health Organization International Patient Safety Event classification. Can J Respir Ther. 2016;52(3):85-91. PMID: 30123023. PMCID: PMC6073515.
4. Lewarski JS, Gay PC. Current issues in home mechanical ventilation.

Chest. 2007;132(2):671-6. https://doi.org/10.1378/chest.07-0558.
5. Ackrivo J, Elman L, Hansen-Flaschen J. Telemonitoring for Home-assisted Ventilation: A Narrative Review. Ann Am Thorac Soc. 2021;18(11):1761-1772. https://doi.org/10.1513/AnnalsATS.202101-033CME.
6. Mansell SK, Cutts S, Hackney I, et al. Using domiciliary non-invasive ventilator data downloads to inform clinical decision-making to optimise ventilation delivery and patient compliance. BMJ Open Respir Res. 2018;5(1):e000238. https://doi.org/10.1136/bmjresp-2017-000238.
7. Pinto A, Almeida JP, Pinto S, Pereira J, Oliveira AG, Carvalho M. Home telemonitoring of non-invasive ventilation decreases healthcare utilization in a prospective controlled trial of patients with amyotrophic lateral sclerosis. J Neurol Neurosurg Psychiatry. 2010;81(11):1238-1242. https://doi.org/10.1136/jnnp.2010.206680.