Telemonitoring for the follow-up of home noninvasive ventilation: a promising future with ongoing challenges

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Shareable abstract (@ERSpublications)
There is no agreement or clear evidence on the usefulness of algorithms using ventilator data predicting deterioration. Future research is needed focusing on algorithms that predict outcomes relevant to patients and the healthcare system. https://bit.ly/4083nL2

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Home noninvasive ventilation (NIV) is a well-established therapy for patients with chronic respiratory failure [1–4]. As the use of home NIV becomes more widespread and increasingly complex, healthcare systems are simultaneously facing a decline in workforce [5, 6]. A promising solution for this challenge is the integration of telemonitoring. It offers significant potential for delivering personalised care; for example, not only in facilitating the initiation of home NIV [7–9] but also during follow-up in order to minimise unnecessary interactions with healthcare providers for stable patients and enable timely interventions for those whose conditions are deteriorating. However, a key challenge lies in managing the large amounts of data generated, identifying which monitoring parameters are predictive of important patient-related outcomes and determining the appropriate actions based on these insights.

Recently, Bianquis *et al.* [10] investigated telemonitoring algorithms designed to identify patients with unsuccessful ventilation during follow-up. They enlisted 11 experts in home NIV to develop a strategy for detecting inadequate ventilation using telemonitored data transmitted by the ventilator. The experts were tasked with creating algorithms that included specific cut-off values or changes in parameters relative to a reference period. They could also specify how long an abnormal value needed to persist to trigger an alert. Additionally, the experts determined the appropriate actions following an alert, such as a call or home visit by the homecare provider, contacting the clinician, or performing overnight oximetry or transcutaneous capnography.

Notably, the algorithms developed by the experts varied significantly in their choice of parameters and cut-off values, and the actions triggered by the alerts. The algorithms demonstrated poor diagnostic performance in identifying inadequately ventilated patients (sensitivity 78% (95% CI 37–95%), specificity 40% (95% CI 19–78%), positive predictive value 72% (95% CI 65–77%) and negative predictive value 45% (95% CI 37–51%)). Furthermore, the algorithms generated numerous alerts, which significantly increased costs and workload for healthcare workers.

While this study is one of the first attempts to develop useful algorithms for telemonitored ventilator data, which are and will be more and more offered and used, our main concern is that the endpoint chosen (a somewhat arbitrary definition of successful ventilation) is probably not the most relevant endpoint. Overall, the goal of home NIV is to improve health-related quality of life, reduce hospitalisation rates and improve survival. Instead, the authors chose as an endpoint the detection of poor ventilation, defined as the failure to meet at least one of the following criteria: 1) adherence >4 h·day^{-1}, 2) improvement in arterial carbon dioxide tension (defined as <6.5 kPa at follow-up or a 0.5-kPa reduction following 1 h on NIV), 3) a residual event rate <10 per h and 4) absence of severe NIV-related side-effects. While we agree that

patients meeting these criteria might not require additional clinical intervention, we believe that the most critical marker of successful NIV is improvement in survival and/or health-related quality of life. However, the criteria used by Bianquis *et al*. [10] have not been shown to improve these outcomes directly. For instance, research indicates a weak relationship between improved gas exchange and enhanced survival [11]. Therefore, the relationship between these criteria and patient-related outcomes such as survival and quality of life remains unclear. An important interim step would be to first identify which parameters are strong predictors of patient-related outcomes. The core conclusion of this paper relies on subjective judgments about what constitutes successful ventilation, the selection of parameters and how these factors interrelate. Even if parameters like usage, leakage, carbon dioxide levels and side-effects are accurately monitored, the algorithms will only be as reliable as the relevance of these factors to meaningful patient outcomes.

A remarkable finding of the study is that many experts, who had the freedom to completely define their own algorithm, incorporated parameters reflecting change over time. This suggests a focus on detecting deterioration or exacerbations, similar to the approach used by Borel *et al.* [12] to predict COPD exacerbations, even though the study did not define this as the primary endpoint for an adequate algorithm. There may be a considerable number of patients on home NIV who meet the criteria for unsuccessful ventilation as defined, yet remain in a relatively stable condition. Additionally, it is worth noting that two criteria for defining unsuccessful ventilation (usage <4 h·day^{-1} and residual events rate >10 per h) are directly measurable through ventilator data. Surprisingly, however, not all experts included these specific criteria in their algorithms, despite the data being readily available.

Another significant aspect of the study is that it leads to increased demands on the healthcare workforce and rising costs, primarily due to additional calls, home visits, and measurements such as oximetry and capnography. While the retrospective design allows for the simultaneous testing of multiple expert algorithms, a significant limitation is the difficulty in determining whether actions triggered by an algorithm provide any benefit to the patient, such as improved care or a reduction of hospitalisations, that justify the associated costs. Given that most algorithms showed poor diagnostic performance in identifying unsuccessful ventilation, it may seem unlikely that the additional workload would lead to meaningful improvements in patient outcomes, and thus cost-effectiveness. To make progress in the field of telemonitoring during the follow-up of patients on home NIV, besides showing that it is effective in improving relevant outcomes, there should be attention to organisational aspects, cost-effectiveness, and budget impact in different healthcare structures and countries.

In conclusion, this paper presents valuable insights into the complexities of managing telemonitored data and the appropriate actions to take in response. The main messages are that even experts in home NIV do not agree on a preferred telemonitoring strategy and that decisions based on expert consensus have proven inadequate for detecting “unsuccessful ventilation”. This study underscores the importance of further research focussing on the effectiveness and cost-effectiveness of telemonitoring during home NIV follow-up in improving clinically relevant outcomes. International initiatives, such as the European Respiratory Society (ERS) Task Force on Telemonitoring and the ERS Clinical Research Collaboration IMPORTANCE (Implications of Positive Airway Pressure and Home Mechanical Ventilation: Towards Optimal Patient Care), aim to harmonise research in this field, including by developing a comprehensive data registry. Future studies should leverage this database to identify the key parameters associated with significant patient outcomes and determine effective strategies for managing telemonitored HNIV data to enhance standard care.

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