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REVIEW ARTICLE

Home Non-invasive Ventilation and Telemonitoring as a Bridge to Lung Transplantation: A Narrative

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ABSTRACT

Patients with advanced lung disease may experience progressive respiratory failure, recurrent exacerbations and loss of functional capacity while awaiting lung transplantation. Home non-invasive ventilation (NIV) can support selected patients with chronic ventilatory failure, particularly those with persistent hypercapnia, while telemonitoring may help clinicians identify problems with adherence, mask leak and ventilator performance between scheduled reviews.

This narrative review discusses the physiological basis, indications, practical delivery and potential role of combining domiciliary NIV with remote monitoring during the pre-transplant period. Evidence from chronic hypercapnic chronic obstructive pulmonary disease (COPD) supports the use of appropriately targeted long-term NIV in selected patients, and studies of tele-assistance suggest that structured remote follow-up can reduce healthcare utilisation in some chronic respiratory populations. Home initiation and remote review may also improve access for patients who live far from specialist centres. However, evidence directly evaluating this combined strategy in lung transplant candidates is sparse. It is therefore not established that home NIV plus telemonitoring independently improves wait-list survival, transplant rates or post-transplant outcomes. The approach should be regarded as an individualized supportive-care pathway rather than a proven transplant-bridging intervention.

Successful implementation requires transplant-team coordination, patient education, predefined escalation pathways, attention to data privacy and regular assessment of symptoms, gas exchange and functional status. Prospective transplant-specific studies are needed to determine clinical effectiveness, safety and cost-effectiveness.

Key words: *Bridge to lung transplantation, end stage lung disease, home non-invasive ventilation, lung transplantation, telemonitoring.*

INTRODUCTION

Lung transplantation is an established treatment option for carefully selected people with advanced lung disease, but access to a suitable donor organ is limited and the period between listing and transplantation can be clinically demanding. Candidates may deteriorate because of worsening gas exchange, acute exacerbations, infection, malnutrition or deconditioning. Maintaining stability and functional reserve during this interval is an important component of pre-transplant care. International guidance emphasizes timely referral, careful assessment of risk and ongoing optimization of potentially modifiable factors in candidates for transplantation.[1] Registry reports also illustrate the scale and complexity of contemporary lung transplantation.[2]

Home NIV is used in selected forms of chronic respiratory failure to augment alveolar ventilation and reduce carbon dioxide retention. Telemonitoring can add a layer of follow-up by transmitting device and physiological data to a clinical team. These interventions have plausible relevance to transplant candidates who have chronic hypercapnia, nocturnal hypoventilation or difficulty attending frequent hospital appointments. Nevertheless, most evidence supporting long-term NIV comes from COPD and other chronic respiratory populations rather than transplant-listed cohorts. The distinction is important: benefits demonstrated in COPD should not automatically be interpreted as proof of improved transplant outcomes. The studies included in this review are summarized in table 1. Not all the studies are transplant-specific and their relevance to transplant candidates is indirect unless otherwise stated.

Home non-invasive ventilation: principles and patient selection

Mechanism and modes

NIV delivers positive-pressure ventilatory assistance through a nasal, oronasal or other non-invasive interface, avoiding an endotracheal or tracheostomy tube. Bilevel ventilation provides a higher inspiratory pressure and a lower expiratory pressure; the pressure difference contributes to inspiratory assistance and increased alveolar ventilation. Settings are individualized according to the underlying disorder, patient comfort, synchrony, gas exchange and sleep-related symptoms. Continuous positive airway pressure may be appropriate for selected sleep-disordered breathing conditions, but it does not provide the same inspiratory pressure support as bilevel NIV.

For chronic hypercapnic COPD, professional guidance recommends considering long-term NIV in selected patients with persistent stable hypercapnia and using settings that meaningfully reduce or normalize $PaCO_2$ when tolerated.[3,4] NIV should be prescribed after assessment of the cause of respiratory failure, coexisting sleep-disordered breathing, interface suitability and the patient's goals. A single $PaCO_2$ threshold should not replace clinical assessment; thresholds and timing differ between guidelines and clinical contexts.

Potential relevance to transplant candidates

The most plausible candidates are those with chronic hypercapnic ventilatory failure, nocturnal hypoventilation or a recognized indication for home mechanical ventilation. In COPD, randomized evidence supports targeted NIV in selected patients with severe stable hypercapnia.[5] Following an acute exacerbation, persistent hypercapnia identifies a subgroup in whom home NIV may prolong the time to readmission or death when added to oxygen therapy.[6] Conversely, the RESCUE trial did not demonstrate a reduction in readmission or death when NIV was initiated in patients with prolonged hypercapnia soon after acute ventilatory support, underscoring the importance of timing and patient selection.[7]

Home NIV may also be considered in selected patients with restrictive chest-wall disease, neuromuscular disorders and other causes of chronic ventilatory failure. In advanced interstitial lung disease, NIV is not a routine disease-modifying treatment; it may be used selectively for symptom relief or coexisting ventilatory failure, with realistic discussion of goals and limitations. Decisions for transplant candidates should be made jointly by respiratory and transplant teams, taking account of disease trajectory, tolerance, secretion burden, aspiration risk and the possibility that increasing support requirements may signal the need for urgent reassessment.

Interfaces: an important qualification

Nasal and oronasal masks remain the usual interfaces for domiciliary NIV. Helmet interfaces have been studied mainly in acute respiratory failure. Trials and physiological studies in acute settings describe potential advantages and limitations, including reduced facial pressure injury in some circumstances, but also issues with CO_2 washout, noise, dead space and patient interaction.[8-10] These findings should not be extrapolated to routine long-term home ventilation. Helmet NIV is not established as a standard domiciliary interface or as a specific bridge-to-transplant strategy; any use would require specialist justification and an appropriate device and monitoring protocol.

Clinical evidence for long-term home NIV

The strongest evidence base relates to chronic hypercapnic COPD. In a multicentre randomized trial, Köhnlein and colleagues found that NIV targeted to substantially reduce hypercapnia improved survival in patients with advanced stable COPD.[5] In the HOT-HMV trial, adding home NIV to oxygen therapy after a life-threatening COPD exacerbation in patients with persistent hypercapnia prolonged the time to readmission or death compared with oxygen alone.[6] These results support careful selection and adequate ventilatory targets rather than indiscriminate prescription.

Evidence is not uniform across all patients. Struik and colleagues found no significant improvement in the primary outcome of respiratory readmission or death when NIV was

initiated relatively early after acute ventilatory support in patients with prolonged hypercapnia.[7] Differences in timing, persistence of hypercapnia, ventilator settings and patient phenotype may explain some of the variation between trials. Home initiation is feasible in selected stable patients: a randomized study by Duiverman and colleagues found that a structured home-initiation pathway was non-inferior to hospital initiation for the main physiological outcome and reduced costs.[11]

These studies support home NIV for established clinical indications. They do not establish that NIV itself increases the likelihood of receiving a donor organ or improves post-transplant survival. For transplant candidates, the relevant outcomes should include not only $PaCO_2$ and hospital admissions but also wait-list status, functional capacity, nutritional status, patient-reported symptoms, delisting and transplantation.

Telemonitoring in home respiratory support

What can be monitored?

Modern ventilators may transmit nightly usage, percentage of nights used, mask leak, delivered pressures, respiratory rate and estimated tidal volume. Depending on the device, additional signals or linked equipment may provide oxygen saturation, heart rate or transcutaneous CO_2. These measurements can help identify prolonged non-use, persistent leak, possible patient–ventilator asynchrony or a change from an individual's baseline. They are not equivalent to a complete clinical assessment: device-derived estimates can be affected by interface type, leak and proprietary algorithms, and should be interpreted alongside symptoms and, when indicated, blood gases or other objective testing.[12]

Telemonitoring is most useful when it is connected to a defined clinical response. A dashboard without an assigned reviewer, alert thresholds or escalation pathway may generate data without improving care. A practical service should specify who reviews incoming information, how frequently it is reviewed, which abnormalities trigger contact, and how urgent deterioration is managed. Patients should know that remote monitoring is not an emergency service and should have clear instructions for seeking immediate help.

Evidence and limitations

In a randomized study of chronic respiratory failure, Vitacca and colleagues reported fewer hospitalizations and exacerbations in patients receiving nurse-centred tele-assistance compared with usual care.[13] Reviews of home NIV monitoring describe the potential value of transmitted ventilator data while emphasizing limitations in data reliability, interpretation and clinical integration.[12] Telemonitoring should therefore be viewed as a method of supporting follow-up, not as a substitute for clinical review.

Remote rehabilitation may complement this model by helping patients maintain activity and exercise capacity when travel to a centre is difficult. A randomized equivalence trial of telerehabilitation in chronic respiratory disease found clinically meaningful benefits, although equivalence with centre-based rehabilitation was not established for every outcome.[14] The relevance to transplant candidates is encouraging but indirect; transplant-specific programmes should monitor safety, adherence and functional outcomes.

Integrating NIV and telemonitoring in the pre-transplant pathway

A coordinated pathway begins with a documented indication for NIV and baseline assessment of symptoms, arterial or capillary blood gases where appropriate, oxygen requirement, sleep-related symptoms, functional capacity and nutritional status. The ventilator should be selected and titrated by a team experienced in home ventilation. Interface fitting, humidification, education and early troubleshooting are central to adherence. Patients and caregivers should be trained to recognize equipment problems and clinical warning signs.

After initiation, the team can review usage and leak trends alongside symptoms and periodic gas-exchange assessment. A fall in use may reflect discomfort, mask problems, anxiety, cognitive or practical barriers, or clinical deterioration. A rising leak or change in delivered ventilation should prompt verification rather than automatic pressure escalation. Increasing oxygen requirement, worsening dyspnoea, fever, altered mental status, reduced exercise tolerance or evidence of acute-on-chronic respiratory failure warrants direct clinical assessment.

For transplant candidates, telemonitoring reports should be incorporated into routine transplant-team discussions. The pathway should not delay in-person assessment, hospital admission or escalation to other forms of support when clinically indicated. It should also protect patient autonomy: consent, data minimization, secure transmission, access controls and clear data-retention policies are required. Connectivity and digital literacy barriers should be anticipated, with telephone or in-person alternatives available.

Potential benefits, risks and implementation barriers

Potential benefits include improved access to specialist review, earlier identification of device-related problems, support for adherence and fewer avoidable journeys to the transplant centre. NIV may improve ventilation and symptoms in appropriately selected patients with chronic hypercapnia. Tele-rehabilitation may help maintain activity. Together, these elements could contribute to a more organized period of outpatient care while a patient awaits transplantation.

Potential harms include false reassurance from apparently stable device data, alert fatigue, delayed escalation, poor

adherence, pressure injury, dryness, aerophagia, sleep disruption and patient or caregiver burden. Telemonitoring may widen inequity when patients lack reliable connectivity, suitable devices or digital skills. Programmes require staffing, technical support and clear accountability. Cost-effectiveness will depend on local geography, baseline admission rates, device costs and the intensity of clinical oversight.

Most importantly, the available evidence does not demonstrate that combined home NIV and telemonitoring reduces wait-list mortality or improves post-transplant survival. The strategy should be presented as a reasonable individualized supportive-care option for selected patients, not as a validated intervention that guarantees maintenance of transplant eligibility.

Table 1. Selected evidence relevant to home NIV, telemonitoring and pre-transplant care

Reference	Study / Population	Design and Principal Finding	Relevance / Limitation
1	Leard et al., lung transplant candidates	ISHLT consensus document on candidate referral, evaluation and selection.	Frames the multidisciplinary pre-transplant pathway.
2	Chambers et al., adult lung transplant registry	Registry report describing recipient characteristics and transplant trends.	Provides transplant context, not evidence for NIV/telemonitoring.
3	Macrea et al., chronic stable hypercapnic COPD	ATS clinical practice guideline.	Supports screening for OSA, reassessment after exacerbation and targeted NIV.
4	Ergan et al., COPD	ERS guideline on long-term home NIV.	Provides evidence-based recommendations for COPD; not transplant-specific.
5	Köhnlein et al., stable hypercapnic COPD	Multicentre randomized trial; NIV targeted to reduce $PaCO_2$ improved survival.	Supports targeted long-term NIV in selected COPD.
6	Murphy et al. (HOT-HMV), persistent hypercapnia after COPD exacerbation	Randomized trial; home NIV plus oxygen prolonged time to readmission or death compared with oxygen alone.	Strong COPD evidence; cannot be assumed to improve transplant outcomes.
7	Struik et al., COPD after acute respiratory failure	Randomized trial; early nocturnal NIV did not significantly improve the primary composite outcome.	Demonstrates importance of timing and selection.
11	Duiverman et al., chronic hypercapnic COPD	Randomized trial of home versus hospital NIV initiation; home initiation was feasible and non-inferior for the principal physiological outcome.	Supports selected home-initiation pathways.
12	Borel et al., home NIV monitoring	Review of ventilator monitoring technology, data reliability and clinical outcomes.	Highlights usefulness and limitations of device-derived data.
13	Vitacca et al., chronic respiratory failure	Randomized tele-assistance trial involving 240 patients; fewer hospitalizations and exacerbations were reported in the intervention group.	Supports structured remote follow-up; not a lung-transplant trial.
14	Cox et al., chronic respiratory disease	Randomized telerehabilitation equivalence trial; meaningful improvements were observed, but equivalence was not established for every outcome.	Supports remote rehabilitation as a possible adjunct; not transplant-specific.

Future directions

Prospective multicentre studies should recruit transplant candidates and report outcomes that matter to patients and transplant programmes. These should include time alive and out of hospital, exacerbations, unplanned admissions, change in $PaCO_2$, functional capacity, quality of life, wait-list removal, transplantation and post-transplant outcomes. Studies should distinguish disease phenotypes and specify NIV indication, timing, settings, adherence and the telemonitoring response protocol.

Implementation research is also needed to define safe alert thresholds, reduce unnecessary alerts and evaluate the workload required for remote review. Patient-reported symptoms should be integrated with device data rather than relying on automated signals alone. Economic analyses should include equipment, connectivity, staffing, travel avoided and hospital utilization. Until such evidence is available, services should audit outcomes locally and avoid attributing changes in transplant outcomes to telemonitoring without an appropriate comparator.

CONCLUSIONS

Home NIV has an established role in selected patients with chronic hypercapnic respiratory failure, particularly when treatment is individualized and directed toward meaningful improvement in ventilation. Telemonitoring can support adherence, identify technical problems and extend specialist follow-up beyond the hospital. These approaches may be useful components of pre-transplant supportive care for carefully selected candidates. However, direct evidence for a combined NIV–telemonitoring bridge-to-transplant strategy remains limited, and effects on wait-list and post-transplant outcomes are unknown. The approach should therefore be implemented within a multidisciplinary pathway, with explicit escalation criteria and prospective outcome evaluation.

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DISCLOSURE

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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