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Editorial

Not All Oxygen is Delivered Equally: Pulse-Dose Versus Continuous Flow in Practice and Physiology

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Abbreviations:

COPD=chronic obstructive pulmonary disease; **DME**=durable medical equipment; **LTOT**=long-term oxygen therapy; **POC**=portable oxygen concentrator

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Introduction

In the United States, more than 1.5 million adults are prescribed long-term oxygen therapy (LTOT) for severe hypoxemia, most commonly due to chronic lung diseases such as chronic obstructive pulmonary disease (COPD) and interstitial lung disease.[1] Home oxygen equipment represents a substantial portion of durable medical equipment (DME) spending in the United States, with Medicare expenditures estimated at $2 billion annually.[2] Several LTOT delivery modalities are available, including compressed oxygen cylinders, liquid oxygen systems, stationary oxygen concentrators, and portable oxygen concentrators (POCs). These modalities differ significantly in size, weight, oxygen supply duration, refilling mechanisms, portability, cost, and air travel compatibility. As a result, the choice of oxygen equipment has practical consequences for mobility, adherence, safety, and quality of life.

The use of POCs, which are generally smaller, lighter, and more compatible with an active lifestyle, has increased markedly over the past decade.[3] This growth reflects the convergence of regulatory, technological, and patient-centered factors.[4] Changes in Medicare coverage criteria have expanded reimbursement eligibility for POCs, while advances in sieve technology have improved device oxygen capacity, battery life, and portability. In addition, Federal Aviation Administration approval of select POC models for in-flight use has expanded the practical utility of these devices for patients who previously faced substantial barriers to air travel. Taken together, these developments have increased the accessibility and desirability of POCs and have reshaped the landscape of LTOT delivery.

This shift has important implications for clinical practice. Although clinicians prescribe LTOT by specifying oxygen dose and duration, the DME supplier often determines the specific equipment a patient receives, commonly providing a combination of systems.[5] For example, patients may use a stationary concentrator at home and then portable equipment, such as compressed oxygen cylinders or POCs, when leaving the house. Patient preference studies suggest that access to POCs in addition to traditional oxygen systems is highly valued.[6] In real-world practice, many patients, therefore, alternate among oxygen delivery modalities throughout the day depending on activity level, setting, battery availability, and perceived benefit.

In this context of frequent device switching and increasing reliance on POCs, clinicians must understand the implications of the prescribed oxygen flow rate. Supplemental oxygen is delivered through 2 primary dosing

strategies: continuous flow and pulse-dose flow. Continuous flow systems, such as stationary concentrators, compressed gas cylinders, and liquid oxygen systems, deliver oxygen at a constant rate throughout the respiratory cycle. Pulse-dose flow systems, such as POCs and oxygen-conserving devices attached to cylinders, deliver a discrete bolus of oxygen early in inspiration, typically triggered by detection of inspiratory effort.

A common misconception in clinical practice is that the numeric setting on a pulse-dose device is equivalent to the same numeric flow rate on a continuous flow system (e.g., a pulse-dose setting of "2" delivers oxygen equivalent to 2L/min by continuous flow).[7] In reality, the relationship between pulse-dose and continuous flow oxygen delivery is neither linear nor fixed. It depends on both patient physiology and device performance. Patient-specific factors, including respiratory rate, tidal volume, inspiratory flow, and breathing pattern, as well as device-specific features, including trigger sensitivity, oxygen purity, bolus volume, and bolus timing, all affect delivered oxygen.[7,8] This complexity is compounded by the absence of standardization across manufacturers: the same numeric pulse-dose setting may deliver significantly different amounts of oxygen depending on the specific device.[9,10] As a result, pulse-dose settings should be interpreted as relative, device-specific indices rather than direct equivalents to continuous flow rates.

These considerations have important implications for LTOT prescribing and strongly support device-specific oxygen titration rather than assumption of equivalence across modalities or between devices. However, many patients undergo formal oxygen titration using continuous flow and subsequently use pulse-dose systems in daily life, often without reassessment. In this scenario, the prescribed oxygen "dose" may not reflect the oxygen actually delivered during activities of daily life. In practice, device-specific evaluation frequently occurs only after equipment has already been dispensed, if it occurs at all, resulting in a critical gap between the oxygen prescription, the equipment provided, and the patient's physiologic response.

Available evidence suggests that pulse-dose systems can approximate continuous-flow oxygenation in selected patients, but this equivalence cannot be assumed. Small randomized crossover studies, conducted primarily in patients with severe COPD, have reported similar mean oxygen saturations with pulse-dose and continuous flow oxygen delivery.[8,11,12] However, group averages can mask clinically important interindividual variability as up to 20% of patients experienced significant exertional desaturation with pulse-dose oxygen.[8,11] Pulse-dose delivery may underperform in physiologic states that impair device triggering or reduce effective oxygen delivery, including rapid shallow breathing during activity, low inspiratory effort during sleep or in neuromuscular weakness, and frequent mouth breathing.[8] Notably, baseline physiologic measures such as forced expiratory volume in 1 second, lung volumes, and resting room air oxygen saturation do not reliably identify which patients will maintain adequate oxygenation with pulse-dose systems during exertion.[8] Therefore, in clinical practice, supplemental oxygen should be titrated using the specific device the patient will use and under conditions that reflect real-world needs (rest, exertion, and sleep, as clinically indicated).

Important evidence gaps persist. First, most comparative studies of oxygen delivery modalities have been conducted in patients with COPD, limiting generalizability to other populations that commonly require LTOT, including patients with interstitial lung disease, pulmonary hypertension, and advanced heart failure. Second, most studies have relied on short-duration, laboratory-based measurements of oxygen saturation. These assessments may not capture fluctuations in oxygen demand during daily activities or prolonged exertion. Third, existing comparative studies have focused largely on physiologic endpoints, such as oxygen saturation and walk distance, with limited evidence regarding clinical outcomes such as hospitalization and survival. These limitations underscore the need for pragmatic studies that evaluate oxygen delivery systems in the settings and populations in which they are actually used.

Continuous-flow oxygen remains the most physiologically robust delivery modality across a broad range of breathing patterns, activity states, and disease types, and it is supported by the strongest historical evidence base. Pulse-dose systems, including POCs, offer significant advantages, including improved portability, mobility, convenience, and oxygen conservation. The challenge is to determine for whom, at what settings, and under what conditions pulse-dose systems provide adequate oxygen delivery. Meeting this challenge will require a more individualized approach to oxygen prescribing. Future work should prioritize the development and validation of predictive models that integrate patient physiology and device-specific performance characteristics to estimate the adequacy of pulse-dose oxygen delivery. Equally important, implementation studies are crucial to define how clinicians, patients, pulmonary function testing laboratories, and DME providers can coordinate timely, device-specific titration before and after equipment is dispensed. Ultimately, aligning the oxygen prescription with the oxygen actually delivered is essential to improving the effectiveness of LTOT in real-world practice.

References

1. Jacobs SS, Krishnan JA, Lederer DJ, et al. Home oxygen therapy for adults with chronic lung disease. An official American Thoracic Society clinical practice guideline. *Am J Respir Crit Care Med.* 2020;202(10):e121-e141. https://doi.org/10.1164/rccm.202009-3608ST

2. Gillen EM, Aurora M, Morley M. Oxygen a Large and Growing Share of Medicare DME Spending. Avalere Health website. Published June 2023. Accessed August 2026. https://advisory.avalerehealth.com/insights/oxygen-a-large-and-growing-share-of-medicare-dme-spending

3. Duan KI, Wong ES, Liao JM, Sabbatini AK, Au DH. Long-term trends in home respiratory medical equipment among U.S. Medicare patients, 2013-2019. *Am J Respir Crit Care Med.* 2022;206(4):509-511. https://doi.org/10.1164/rccm.202202-0238LE

4. Glezer S, Hess MW, Kamada AK. Patient use patterns of portable oxygen concentrators. *Pulm Ther.* 2024;10:123-132. https://doi.org/10.1007/s41030-024-00252-4

5. Krishnan JA, Bracken NE, Cerretta S, et al. What oxygen equipment do patients with COPD have at home? Ancillary results of the PELICAN dtudy. *Am J Respir Crit Care Med.* 2017;195(Supplement_1):A4715. https://academic.oup.com/ajrccm/article/195/Supplement_1/A4715/8601464

6. Dakkak J, Tang W, Smith JT, et al. Burden and unmet needs with portable oxygen in patients on long-term oxygen therapy. *Ann Am Thorac Soc.* 2021;18(9):1498-1505. https://doi.org/10.1513/AnnalsATS.202005-487OC

7. McCoy RW. Options for home oxygen therapy equipment: storage and metering of oxygen in the home. *Respir Care.* 2013;58:65-81. https://doi.org/10.4187/respcare.01932

8. Gloeckl R, Jarosch I, Schneeberger T, et al. Comparison of supplemental oxygen delivery by continuous versus demand based flow systems in hypoxemic COPD patients - a randomized, single-blinded cross-over study. *Respir Med.* 2019;156:26-32. https://doi.org/10.1016/j.rmed.2019.08.001

9. Palwai A, Skowronski M, Coreno A, Drummond C, McFadden ER, Jr. Critical comparisons of the clinical performance of oxygen-conserving devices. *Am J Respir Crit Care Med.* 2010;181(10):1061-1071. https://doi.org/10.1164/rccm.200910-1638OC

10. Zhou S, Chatburn RL. Effect of the anatomic reservoir on low-flow oxygen delivery via nasal cannula: constant flow versus pulse flow with portable oxygen concentrator. *Respir Care.* 2014;59(8):1199-1209. https://doi.org/10.4187/respcare.02878

11. Garrod R, Bestall JC, Paul E, Wedzicha JA. Evaluation of pulsed dose oxygen delivery during exercise in patients with severe chronic obstructive pulmonary disease. *Thorax.* 1999;54(3):242-244. https://doi.org/10.1136/thx.54.3.242

12. Gloeckl R, Osadnik C, Bies L, Leitl D, Koczulla AR, Kenn K. Comparison of continuous flow versus demand oxygen delivery systems in patients with COPD: a systematic review and meta-analysis. *Respirology.* 2019;24(4):329-337. https://doi.org/10.1111/resp.13457