Understanding FiO_2 Levels in EMS Transport Ventilation

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Abstract:

Oxygen therapy is a critical intervention in emergency medical services (EMS), particularly for patients requiring mechanical ventilation during prehospital transport. While the fraction of inspired oxygen (FiO_2) plays a pivotal role in systemic oxygenation and the stabilization of critically ill patients, initiating ventilation with high oxygen concentrations offers immediate benefits in correcting hypoxemia. Based on established guidelines—including those from the AHA, ERC, and BTS—current evidence supports starting mechanical ventilation with 100% FiO_2, followed by careful titration based on clinical status to maintain arterial oxygen saturation (SpO_2) targets and mitigate the risk of hyperoxia.

Although much of the research on FiO_2 toxicity originates from intensive care unit (ICU) settings, EMS presents a distinct clinical scenario that can still benefit from ICU findings. Unlike ICU patients, who may undergo prolonged ventilation for days or weeks, EMS transport times are generally short—typically lasting minutes to a few hours. This limited exposure significantly reduces the likelihood of oxygen toxicity.

Recent studies indicate that the brief duration of high FiO_2 use in EMS is not associated with adverse outcomes, particularly when oxygen levels are adjusted in response to peripheral oxygen saturation (SpO_2) monitoring. Establishing a standardized protocol for initiating mechanical ventilation with high FiO_2 in EMS ensures rapid correction of hypoxemia while allowing for timely adjustments. This white paper reviews the relevant literature, emphasizing the benefits of high initial FiO_2 in EMS and highlighting the need for evidence-based oxygenation strategies tailored to the prehospital environment.

Introduction:

Effective oxygen management is a critical component of EMS, ensuring adequate oxygenation for critically ill patients during transport. The fraction of inspired oxygen (FiO_2) plays a key role in respiratory support, directly affecting arterial oxygenation and systemic oxygen delivery. In prehospital settings, where rapid intervention is essential, optimizing FiO_2 administration requires adherence to clinical guidelines and real-time patient monitoring. Discussions on FiO_2 use in EMS often center around balancing the need for immediate hypoxemia correction with concerns about prolonged oxygen exposure. Although ICU research has examined the long-term effects of high FiO_2, EMS transport presents a distinct clinical scenario due to its significantly shorter exposure durations and immediate stabilization objectives. Given these differences, FiO_2 administration strategies should be evaluated within the EMS context to ensure evidence-based decision-making. This paper reviews FiO_2 use in EMS ventilation, including clinical guidelines, available evidence, and physiological considerations relevant to prehospital mechanical ventilation. A focus on FiO_2 management within transport timelines ensures alignment with best practices, optimizing patient outcomes while minimizing potential risks associated with excessive oxygen exposure.

Understanding Oxygenation and FiO_2 in Prehospital Care

Oxygen is essential for cellular metabolism, organ function, and tissue viability. Even brief periods of inadequate oxygenation can result in irreversible cellular injury and organ dysfunction (Sarkar et al., 2017). The fraction of inspired oxygen (FiO_2) refers to the percentage of oxygen in the inhaled gas mixture, with ambient air containing approximately 21% oxygen (Fuentes & Chowdhury, 2022). In clinical settings, FiO_2 is a primary determinant of arterial oxygenation and systemic oxygen delivery, particularly in patients with respiratory failure who require mechanical ventilation. Hypoxemia refers to a decrease in arterial oxygen partial pressure (PaO_2) and can lead to cellular hypoxia, metabolic dysfunction, and multi-organ failure if uncorrected (Rhodes et al., 2022). Hypoxia, a broader term, describes inadequate oxygen availability at the tissue level, which may result from insufficient oxygen delivery, impaired oxygen uptake, or increased metabolic demand (Sarkar et al., 2017). To optimize oxygenation, FiO_2 adjustments must balance the need for adequate oxygen delivery while minimizing the risks associated with excessive oxygen exposure (Mora Carpio et al., 2023). Prolonged exposure to high FiO_2 can induce oxidative stress, alveolar damage, and lung injury, particularly in ICU patients receiving mechanical ventilation for extended durations (Della Rocca et al., 2022). However, these effects are time-dependent, and significant pulmonary toxicity typically occurs with FiO_2 exposure beyond 24 to 48 hours (Patel, 2024).

Comparing ICU and EMS Oxygen Strategies

The administration of supplemental fractional oxygen (FiO_2) is a life-sustaining therapy in critical care, used in the management of over a million patients annually to support respiratory function and maintain adequate oxygenation (Pannu et al., 2022). However, oxygen therapy strategies differ significantly between intensive care units (ICUs) and emergency medical services (EMS) due to variations in treatment duration, monitoring capabilities, and patient stabilization goals. In ICUs, FiO_2 must be carefully titrated to maintain oxygenation while minimizing the risks associated with both hypoxemia and hyperoxia (Pannu et al., 2022). The respiratory and cardiovascular systems are the primary regulators of oxygen transport and homeostasis, and dysfunction in either can lead to hypoxemia and its associated complications (Sarkar et al., 2017). Oxygen therapy is particularly critical for patients with hypoxemic respiratory failure, where immediate intervention is necessary to prevent fatal outcomes (Martin & Grocott, 2025). Mechanical ventilation is often required to support increased oxygen demand and reduce the work of breathing in critically ill or severely injured patients (Baez et al., 2022). In such cases, FiO_2 levels must be carefully titrated based on patient needs, with pulse oximetry (SpO_2) and arterial blood gas (ABG) analysis guiding adjustments to ensure optimal oxygen delivery (Abraham et al., 2023). Even brief episodes of hypoxia can lead to cellular injury and organ dysfunction, emphasizing the importance of rapid oxygenation in critically ill patients (Della Rocca et al., 2022).

Emergency medical services (EMS) operate in a time-sensitive environment, with the primary goal of immediate stabilization and transport to definitive care. Unlike ICU patients who may require prolonged oxygen therapy, EMS protocols prioritize rapid oxygenation in critical patients, with FiO_2 titration reducing exposure risk as transport progresses. Given these constraints, FiO_2 administration in EMS is initiated at 100% for rapid correction of hypoxemia, followed by adjustments based on continuous monitoring through pulse oximetry or ABG analysis when available (Abraham et al., 2023). However, whereas ICU patients may experience oxygen toxicity due to prolonged exposure, EMS transport durations are significantly shorter, reducing this risk when FiO_2 is properly managed. Despite the differences in care environments, both ICU and EMS providers must balance oxygen administration to optimize oxygenation while avoiding unnecessary exposure. The EMS approach to FiO_2 use prioritizes immediate stabilization during transport, while ICU management focuses on long-term regulation to prevent complications related to prolonged oxygen therapy.

Defining Safe FiO_2 Limits for EMS Transport:

The optimal FiO_2 level and duration of exposure required to avoid oxygen-related complications remain subjects of ongoing investigation. While there is broad agreement that sustained exposure to high concentrations of oxygen can contribute to pulmonary injury, no universally accepted FiO_2 threshold or exact exposure duration has been established (Lee, 2013).

Oxygen toxicity is recognized as both dose- and time-dependent, with risk increasing as FiO_2 levels and exposure time extend (Cooper et al., 2023). Notably, tissue injury associated with excessive oxygen typically occurs after prolonged administration (Chawla & Lavania, 2001), far beyond the exposure times seen in emergency medical services (EMS) transport.

Clinical recommendations advise reducing FiO_2 to 60% or lower within 12 hours of intubation to minimize the risk of oxygen toxicity (Lee, 2013, p. 12). This guidance reflects practices intended for intensive care settings, where mechanical ventilation is sustained over longer durations. In contrast, EMS transport generally lasts only minutes to a few hours—well below this 12-hour threshold. Accordingly, FiO_2 administration during EMS transport remains within accepted safety limits.

Evidence from Human Studies on FiO_2 Tolerance

Research on human tolerance to high FiO_2 concentrations indicates that the lungs can sustain elevated oxygen exposure for controlled durations before significant pulmonary effects develop. At sea-level atmospheric pressure, continuous exposure to FiO_2 = 1.0 (100%) for 24–48 hours has been reported as generally well tolerated, without severe pulmonary injury (Cooper et al., 2023). Mild, transient symptoms have only been noted after approximately 12 hours of exposure, varying with the administered oxygen concentration. These effects are self-limiting and do not indicate lasting pulmonary injury (Hochberg et al., 2021).

One of the earliest systematic investigations into human oxygen tolerance examined the physiological effects of high FiO_2 exposure in healthy volunteers. Participants who inhaled 100% oxygen for up to 24 hours remained asymptomatic for the first 12 hours. Between 12 and 16 hours, some developed mild, temporary symptoms, including cough, substernal chest discomfort, and a reduction in vital capacity (VC). Importantly, no participants experienced severe pulmonary dysfunction or long-term complications (Hochberg et al., 2021). Further studies expanded these findings by assessing different oxygen concentrations:

- FiO_2 = 50% for 24 hours resulted in no detectable symptoms.
- FiO_2 = 75% for 24 hours caused mild, late-onset effects (Hochberg et al., 2021).

Another early research has indicated that at sea-level atmospheric pressure, “100% oxygen is safe if given for up to six hours; 70% oxygen is safe for 24 hours; and after this time, 45% should be the approximate upper limit to the FiO_2” (Tinits, 1983, p. 326). Since EMS transport durations typically range from only minutes to a few hours, these findings specifically address prolonged oxygen exposure exceeding the duration of prehospital care. Consequently, oxygen toxicity concerns identified in longer-term exposure scenarios do not directly translate to EMS settings. Furthermore, current clinical guidelines and recommendations explicitly support the initial use of high FiO_2 during prehospital care to rapidly manage critical hypoxemia, underscoring its necessity and established safety profile within EMS practice.

These studies demonstrate that early symptoms of high FiO_2 exposure, when present, tend to be mild and self-resolving within controlled environments. The clinical relevance of these findings to EMS is significant, as FiO_2 exposure durations during transport are substantially shorter than those assessed in research settings. While prolonged oxygen exposure beyond established thresholds can contribute to pulmonary effects, the brief nature of EMS transport minimizes the likelihood of clinically significant oxygen-related complications.

Physiological Effects of Short-Term High FiO_2 Exposure

Early respiratory symptoms associated with high FiO_2 exposure, such as cough and chest discomfort, are not direct indicators of oxygen toxicity but are instead linked to physiological changes, including nitrogen washout and absorptive atelectasis (Hochberg et al., 2021).

Nitrogen Washout and Alveolar Changes

Nitrogen washout occurs when high oxygen concentrations displace nitrogen in the alveoli, reducing alveolar stability and predisposing certain lung units to transient collapse (atelectasis) (Hochberg et al., 2021). This ventilation-perfusion mismatch can contribute to mild respiratory symptoms in some individuals but does not represent irreversible lung injury. A controlled study demonstrated this effect by exposing healthy volunteers to a gas mixture of 50% oxygen and 50% nitrogen at 2 atmospheric pressure for three hours. Participants experienced no substernal chest discomfort, supporting the role of alveolar nitrogen in maintaining lung stability (Hochberg et al., 2021).

Resolution of Symptoms After FiO_2 Adjustment

Research indicates that transient symptoms associated with high FiO_2 exposure tend to resolve rapidly once oxygen concentration is reduced. Pulmonary symptoms, including mild airway irritation, typically subside within four hours following the discontinuation of 100% oxygen (Chawla & Lavania, 2001). This suggests that early symptoms observed during FiO_2 administration in EMS transport are temporary physiological responses rather than indicators of long-term pulmonary damage.

Dose and Time-Dependent of Oxygen Toxicity

Although physiological changes can occur with high oxygen exposure, clinically significant pulmonary effects are strongly time-dependent. Research has shown that pulmonary function tests (PFTs) detect measurable declines in lung function only after approximately 24 hours of continuous 100% oxygen exposure (Jackson, 1985). Severe pulmonary complications associated with prolonged high FiO_2 exposure, including diffuse alveolar damage, have been reported in settings where exposure durations exceed 48 hours (Bitterman, 2009). These findings reinforce the importance of differentiating prolonged oxygen exposure risks from short-term FiO_2 administration during EMS transport. Given that prehospital transport times are significantly shorter than 24 hours, the likelihood of oxygen-related lung injury during EMS transport remains low.

Histopathological Insights into Long-Term Oxygen Exposure Risks

Early histopathologic evidence linking prolonged exposure to high fractions of inspired oxygen (FiO_2) with lung injury was established through autopsy studies conducted in the 1960s and 1970s. One study analyzed lung tissue from 70 patients who had undergone prolonged mechanical ventilation (MV) and compared their findings with control patients who had died without MV exposure (Hochberg et al., 2021). The study identified distinct pathological changes in lung tissue, consistent with early exudative and later proliferative stages of what is now recognized as diffuse alveolar damage (DAD). Notably, these findings were most frequently observed in patients mechanically ventilated for more than 10 days with an FiO_2 greater than 0.9 (Hochberg et al., 2021). These results highlight the time-dependent nature of oxygen toxicity, where prolonged high-FiO_2 exposure is associated with progressive lung injury. Importantly, the lung injury patterns observed in these autopsy studies occurred under conditions of extended FiO_2 administration in ICU settings, rather than the brief exposure durations encountered in emergency medical services (EMS) transport. The study findings are specific to continuous, high-FiO_2 exposure over multiple days, far exceeding the timeframes of prehospital oxygen therapy. Therefore, concerns derived from prolonged ICU exposure should not be inappropriately extrapolated to short-duration prehospital oxygen administration, as the exposure conditions and clinical environments differ significantly.

Assessing Oxygen Toxicity Risks in Prehospital Transport

When evaluating the potential for oxygen toxicity in emergency medical services (EMS) transport, it is essential to compare established oxygen exposure thresholds with actual EMS transport durations. Oxygen toxicity is a time-dependent phenomenon, meaning that the duration of high FiO_2 exposure is a critical factor in determining clinical risk. Available data consistently demonstrate that prehospital transport durations are significantly shorter than the exposure times associated with pulmonary or systemic oxygen toxicity. This distinction emphasizes the importance of contextualizing oxygen toxicity concerns within the actual timeframe of EMS care, ensuring that risk assessments reflect real-world prehospital conditions rather than prolonged intensive care unit (ICU) exposures.

Ground EMS Transport Durations

Ground ambulances are the primary mode of EMS transport, accounting for the majority of prehospital patient transfers globally. Transport times vary based on geographic location, population density, traffic conditions, and hospital accessibility. However, research consistently demonstrates that oxygen administration during EMS transport is significantly shorter than the exposure times associated with pulmonary oxygen toxicity.

- A nationwide study analyzing 410,187 EMS activations for suspected stroke in the U.S. found that 98% of transports occurred via ground EMS, with a median total prehospital time of 35 minutes (IQR: 27–45 minutes) and a 90th percentile of 58 minutes (Cash et al., 2022). The transport phase alone, from scene departure to hospital arrival, had a median duration of 11 minutes (IQR: 7–18 minutes), demonstrating that the majority of prehospital oxygen exposure occurs within a limited timeframe.
- A multi-center study evaluating trauma patients transported to six Level I trauma centers across Colorado, Kansas, Texas, and Missouri reported a median total prehospital time of 44 minutes (IQR: 33–63 minutes), with a median transport time of 18 minutes (IQR: 13–28 minutes) (Jarvis et al., 2021). These findings further support that oxygen administration during EMS transport occurs within short timeframes, differing significantly from prolonged hospital-based oxygen therapy.
- In Denmark, where rural transport distances are longer, a study of 10,939 emergency transports found that highest-priority (lights and sirens) transports had a median duration of 22.6 minutes (IQR: 12.6–33.1 minutes), while lower-priority transports had a median duration of 24.6 minutes (IQR: 13.0–38.4 minutes) (Valentin et al., 2024). Even in regions with longer transport times, the duration of FiO_2 exposure remains within safe limits compared to prolonged oxygen administration scenarios in intensive care settings.

The median and 90th percentile transport times for ground EMS transports remain well below the durations known to contribute to oxygen toxicity. Most EMS transports occur within minutes to under an hour, with rare cases in rural or remote areas exceeding a few hours. These findings underscore the importance of contextualizing oxygen exposure risk based on EMS transport times. Due to the brief nature of prehospital oxygen administration, the assessment of FiO_2 delivered by EMS should be based on the transport duration rather than relying on findings from prolonged ICU oxygen therapy studies.

Impact of Hospital Offload Delays on Oxygen Exposure

In addition to EMS transport durations, hospital offload delays can contribute to the total duration of oxygen administration in prehospital patients. These delays occur when emergency departments (EDs) experience overcrowding, leading to longer transfer times from EMS stretchers to hospital beds. While such delays can increase cumulative FiO_2 exposure, available data indicate that total exposure times remain well within safety thresholds.

A statewide analysis of 3,280,029 ambulance offloads in New York (2021–2022) found that:

- 91% of EMS patients were transferred to hospital care within 30 minutes.
- 8% experienced offload delays ranging from 30 minutes to 2 hours.
- Only 0.1% had delays exceeding 2 hours (New York Bureau of Emergency Medical Services, 2022).

Although delays beyond two hours are rare, even in these cases, total oxygen exposure—including transport and waiting times—remains well below thresholds associated with oxygen toxicity.

Clinical Importance of Timely Hypoxia Management

Timely recognition and management of hypoxia are critical to prevent severe complications and improve patient outcomes. Hypoxia, characterized by insufficient oxygen levels in the body's tissues, can lead to irreversible organ damage and increased mortality if not promptly addressed. Evidence from various studies underscores the importance of early intervention in hypoxic conditions:

- **Organ Damage Prevention:** Immediate recognition and treatment of hypoxia is essential to prevent permanent organ damage and potential fatality. Effective management strategies include maintaining airway patency, increasing the oxygen content in inspired air, and optimizing diffusion capacity (Bhutta et al., 2024).
- **Increased Mortality in Hospitalized Patients:** In a prospective study of 100 patients hospitalized on general medicine services, it was reported that episodic hypoxemia—defined as an arterial oxygen saturation below 90% lasting at least 5 consecutive minutes—occurred in 26% of patients. During a follow-up period of 4 to 7 months, the mortality rate was significantly higher among patients who experienced hypoxemia (32%) compared to those without hypoxemia (10%), even after adjusting for severity of illness. The relative risk of death associated with episodic oxygen desaturation was 3.3. Additionally, the severity and duration of desaturation episodes, measured by the saturation-time index, were inversely correlated with survival time (Bowton et al., 1994).
- **Functional Deterioration Post-Hospitalization:** Research indicates that patients admitted with acute hypoxemic respiratory failure often experience a decline in functional status after discharge. In a study involving 151 patients, two-thirds exhibited functional deterioration by at least one grade at discharge, highlighting the necessity of prompt hypoxia management to preserve functional outcomes (Simon et al., 2024).
- **Impact on Traumatic Brain Injury (TBI) Outcomes:** In cases of major traumatic brain injury, the concurrent occurrence of hypoxia and hypotension has been linked to significantly increased mortality. A study found that patients experiencing both conditions had an adjusted odds ratio for death of 6.1, compared to those with neither condition. This underscores the importance of early oxygenation and blood pressure stabilization in TBI patients (Spaite et al., 2017).
- **'Silent Hypoxia' in COVID-19 Patients:** Hypoxia is a time-sensitive condition strongly associated with poor clinical outcomes (Waruru et al., 2024). The

phenomenon of 'silent hypoxia,' where patients exhibit critically low oxygen levels without apparent respiratory distress, has been observed in COVID-19 cases. Early detection and management of silent hypoxia are vital, as delayed intervention can lead to rapid deterioration and increased mortality (Couzin-Frankel, 2020). A large retrospective study of 1,124 hospitalized COVID-19 patients in Kenya, 81.4% were hypoxic at admission (SpO_2 ≤94%), and hypoxia was significantly associated with increased mortality—even in patients without dyspnea. Mortality was 38% among hypoxic patients compared to 13.6% in non-hypoxic patients (Waruru et al., 2024). These findings reinforce the critical importance of identifying and managing hypoxia early, regardless of symptom presentation.

Clinical Guidelines and Recommendations for FiO_2 Titration

Titration of the fraction of inspired oxygen (FiO_2) in mechanically ventilated patients during EMS transport is critical to maintaining adequate oxygenation while minimizing unnecessary prolonged exposure to high FiO_2 levels. Hypoxia is an immediate and significant concern in prehospital care, contributing to increased mortality and worsened outcomes (AHA, 2020; ERC, 2021). International clinical guidelines provide a structured approach to FiO_2 administration in critically ill patients requiring mechanical ventilation:

- The American Heart Association (AHA, 2020), European Respiratory Society (ERS, 2019), and European Resuscitation Council (ERC, 2021) recommend initiating 100% FiO_2 during resuscitation and mechanical ventilation to correct hypoxemia in critically ill patients rapidly (AHA, 2020).
- FiO_2 should be titrated down to maintain SpO_2 between 94-98% as soon as oxygenation stabilizes, reducing unnecessary oxygen exposure (BTS, 2017).

Target Oxygen Saturation (SpO_2) Levels

Following initial stabilization, maintaining appropriate oxygen saturation (SpO_2) levels is crucial in patient management to ensure adequate tissue oxygenation while avoiding complications associated with hypoxemia and hyperoxia. Established clinical guidelines provide specific SpO_2 targets tailored to various patient conditions:

- **General Adult Patients:** For most acutely ill patients without risk factors for hypercapnic respiratory failure, the British Thoracic Society (BTS) recommends a target SpO_2 range of 94–98% to balance oxygenation and minimize potential excessive oxygenation (BTS, 2017).
- **Patients at Risk of Hypercapnic Respiratory Failure:** In patients with COPD or conditions associated with chronic respiratory failure, oxygen should be administered if SpO_2 is less than 88%, aiming for a target range of 88–92%. This strategy helps prevent hypoxemia while minimizing the risk of carbon dioxide retention and respiratory acidosis. (BTS, 2017).
- **Post-Cardiac Arrest Patients:** In a retrospective observational study involving 2,836 post-cardiac arrest patients identified that maintaining peripheral oxygen saturation (SpO_2) within the range of 95–97% was associated with an increased likelihood of patients being discharged home, reflecting improved clinical outcomes. Conversely, lower SpO_2 levels (≤89–92%) correlated with higher hospital mortality rates and reduced favorable discharge outcomes (Zhou et al., 2021). Supporting these findings, the Australian and New

Zealand Committee on Resuscitation (ANZCOR, 2025) recommends that, following the return of spontaneous circulation (ROSC), inspired oxygen should be carefully titrated to achieve a target oxygen saturation of 94–98%. This recommendation aims to avoid both hypoxia and hyperoxia, highlighting the importance of controlled oxygen administration to minimize potential risks while ensuring adequate oxygenation (ANZCOR, 2025).

- **Acute Stroke Patients:** For individuals suffering from acute stroke, ANZCOR suggests maintaining a SpO_2 between 94–98%, providing sufficient oxygenation without contributing to potential oxidative stress.

Best Practices for FiO_2 Adjustment in EMS Mechanical Ventilation

National EMS protocols, such as those outlined in the National Model EMS Clinical Guidelines (NASEMSO, 2021), align with international standards by recommending initial FiO_2 administration of 100%, followed by titration to maintain SpO_2 at or above 94% once the patient is stabilized (NASEMSO, 2021). This approach prioritizes early hypoxia correction while integrating controlled oxygen titration to avoid prolonged hyperoxia exposure (Pannu et al., 2022).

Oxygen Supply in EMS Transport

Managing oxygen supply is a vital aspect of mechanical ventilation during EMS transport. For critically ill or intubated patients, maintaining adequate oxygenation requires careful coordination of several variables, including cylinder size, pressure settings, FiO_2 concentration, the patient's minute ventilation, and transport duration. EMS providers routinely make real-time decisions that ensure oxygen delivery aligns with the patient's physiological demands while accommodating the operational challenges of prehospital care. This structured approach to oxygen management allows for effective stabilization and continuous ventilation, even during extended or complex transfers.

Portable Oxygen Cylinder Capacity in EMS

Oxygen in EMS is typically delivered via portable, high-pressure cylinders, which vary in capacity and directly influence the available oxygen reserve during transport. The two most widely used cylinder types are:

- **E-cylinder:** approximately 680 liters of compressed oxygen.
- **M-cylinder:** approximately 3,455 liters of compressed oxygen.

The duration of available oxygen depends on multiple factors, including cylinder volume and starting pressure, FiO_2 setting, and the patient's ventilatory demand—specifically their minute volume, which is defined as the total volume of gas inhaled and exhaled per minute.
A standard adult minute volume is approximately 5 L/min but may vary with clinical condition and ventilator settings.
The FiO_2 setting significantly affects cylinder depletion rates:

- **At 100% FiO_2,** all inspired gas is drawn from the oxygen cylinder, making the oxygen flow equivalent to the full minute ventilation.
- **At 60% FiO_2,** the ventilator blends ambient air with cylinder oxygen, reducing total oxygen consumption and extending cylinder life.

Balancing FiO_2 Titration and Oxygen Conservation in EMS

The duration of oxygen supply is determined by the selected FiO_2 setting and the patient's ventilatory requirements. Minute ventilation directly affects oxygen consumption when a ventilator is in use. A commonly used baseline for minute ventilation in an adult patient is 5 L/min, though individual needs may vary based on clinical condition.

- When the ventilator is set to deliver 100% FiO_2, all inhaled gas is supplied directly from the oxygen cylinder. Under these conditions, an E-cylinder, with a total capacity of 680 liters, can provide oxygen for approximately 136 minutes (2.3 hours), while an M-cylinder, with a capacity of 3,455 liters, can sustain ventilation for around 691 minutes (11.5 hours) before depletion.

- When FiO_2 is adjusted to 60%, the ventilator entrains ambient air, thereby reducing the direct oxygen consumption from the cylinder. This adjustment conserves oxygen while maintaining appropriate oxygenation. At this setting, the oxygen requirement decreases, allowing the same E-cylinder to last approximately 226 minutes (3.8 hours), while the M-cylinder extends to about 1,151 minutes (19.2 hours).

These estimations confirm that the available oxygen supply in portable cylinders meets the operational demands of EMS transport, even in prolonged transport scenarios or unexpected delays.

Ensuring an Adequate Oxygen Supply Throughout EMS Transport

Analysis of oxygen consumption in EMS transport demonstrates that portable oxygen cylinders provide adequate FiO_2 delivery even in prolonged transport scenarios. The ability to adjust FiO_2 settings to 60% in the e700 transport ventilator further optimizes oxygen utilization, ensuring that mechanically ventilated patients receive continuous oxygen support throughout prehospital transport. By monitoring cylinder pressure, ventilatory demand, and FiO_2 selection, EMS providers can ensure that oxygen supply remains sufficient for the duration of transport, mitigating risks of depletion even in cases of extended prehospital care.

Evidence-Based Oxygen Delivery in EMS Transport Ventilation

The e700 transport ventilator is designed to align with evidence-based prehospital oxygenation strategies, providing two FiO_2 settings: 100% and 60% to optimize oxygen delivery in EMS transport. This dual-level system enables rapid hypoxia correction during initial stabilization while allowing for controlled FiO_2 titration to prevent unnecessary prolonged high-oxygen exposure.

The 100% FiO_2 setting ensures that critically ill patients receive immediate oxygen support, following established EMS protocols that prioritize oxygenation in life-threatening conditions (NASEMSO, 2021; AHA, 2020). The 60% FiO_2 setting allows EMS providers to adjust oxygen delivery once stabilization is achieved, reducing FiO_2 while maintaining adequate oxygenation, consistent with international guideline recommendations (BTS, 2017; ERC, 2021). By integrating this FiO_2 option, the e700 transport ventilator also supports oxygen resource management, particularly in longer transport scenarios where oxygen conservation is necessary.

Conclusion

Ensuring prompt recognition and correction of hypoxemia is a clinical priority in emergency medical services (EMS), as timely interventions directly impact patient outcomes. Hypoxemia is a recognized contributor to increased morbidity and mortality, with even brief episodes of oxygen desaturation linked to irreversible organ injury and reduced survival. Therefore, rapid administration of high fractional inspired oxygen (FiO_2), particularly at 100%, is clinically indicated to promptly restore adequate oxygenation during the initial phase of prehospital management.

International guidelines from authoritative bodies, including the American Heart Association (AHA) and the European Resuscitation Council (ERC), recommend initiating oxygen therapy at 100% FiO_2 in critically ill patients to correct hypoxemia rapidly. This recommendation is based on clinical evidence demonstrating that prompt reversal of hypoxia significantly reduces the risk of neurological impairment, organ dysfunction, and mortality in acute, time-sensitive scenarios.

Clinical guidelines further advise titrating FiO_2 to maintain targeted oxygen saturation (SpO_2) ranges, typically between 94% and 98% for most patients. While adjusting FiO_2 is recommended once oxygenation stabilizes, practical constraints in prehospital care—such as short transport durations or unstable patient conditions—often limit opportunities for precise titration to lower concentrations. In these situations, continuous pulse oximetry serves as the primary tool for guiding real-time oxygen therapy decisions.

Concerns regarding oxygen toxicity primarily stem from studies conducted in intensive care units (ICUs), where high FiO_2 is administered over extended periods, typically ranging from days to weeks. In contrast, EMS transport durations are significantly shorter—usually ranging from minutes to a few hours—well below the exposure durations associated with clinically significant pulmonary oxygen toxicity. Published studies on human oxygen exposure tolerance indicate that pulmonary effects related to 100% FiO_2 generally occur after prolonged exposures exceeding 6 to 12 hours. Therefore, during EMS transport, exposure to high FiO_2 remains well below established toxicity thresholds. Within this limited timeframe, the clinical priority remains the timely correction of hypoxemia.

Considering these conditions, the routine initiation of 100% FiO_2 in the early phase of EMS care is consistent with evidence-based guidelines and established best practices. The short duration of prehospital transport—well below exposure thresholds reported in published studies—combined with the urgency of treating hypoxia, supports the use of 100% FiO_2 as an initial intervention, with subsequent titration guided by clinical monitoring. The goal is not prolonged hyperoxia but the immediate reversal of tissue hypoxia to reduce preventable harm.

In alignment with these clinical considerations and guideline recommendations, the E700 ventilator provides fixed FiO_2 settings of 100% and 60%, accommodating both the immediate need for high-concentration oxygen delivery and enabling basic titration during prehospital care. The 100% FiO_2 setting aligns with recommendations for initial management of acute hypoxemia in critically ill patients, where rapid oxygenation is critical. The 60% setting allows for a controlled reduction in FiO_2, guided by continuous pulse oximetry, and may be useful during patient stabilization or extended transport.

FiO_2 levels below 60% are generally more applicable in prolonged or in-hospital care settings, where time, diagnostic resources, and patient stability allow for individualized and precise adjustments. Moreover, the evidence reviewed in this paper indicates that EMS transport durations are typically brief. In this phase of care, the primary focus remains on maintaining adequate oxygenation and preventing desaturation rather than lowering FiO_2 to levels that could risk insufficient oxygen delivery. Prehospital care often relies on simplified, high-reliability interventions to support immediate physiological needs, with further FiO_2 titration deferred to the in-hospital phase, where comprehensive reassessment is possible.

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