Aiming low: Can minimizing fraction of inspired oxygen during endobronchial valve placement reduce postprocedural pneumothorax?

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The clinical question

Does low fraction of inspired oxygen (FiO2) during endobronchial valve placement reduce incidence of postprocedural pneumothorax (PTX) in patients with emphysema?

AABIP take home message

In this before-and-after cohort study, an FiO2 titrated to maintain oxygen saturation ≥ 89% during endobronchial valve placement significantly reduced postprocedural PTX compared to a routine, higher FiO2 strategy.

Limited data also suggest that low intraprocedural FiO2 may delay PTX development, a potential safety consideration that requires further characterization.

Background

- In advanced emphysema, severe hyperinflation leads to frequent exacerbations, reduced quality of life, and earlier mortality, even with maximal medical therapy.
- Bronchoscopic lung volume reduction (BLVR) with endobronchial valves (EBVs) is an effective, minimally invasive alternative to surgical interventions for carefully selected patients with severe emphysema.
- EBVs can improve respiratory mechanics by inducing atelectasis (ATX) of the hyperinflated target lobe, improving dyspnea, activity tolerance, and quality of life.
- However, one-fourth to one-third of cases are complicated by postprocedural pneumothorax (PTX).
- Current practice: The rapidity of lobar volume shift after EBV placement is hypothesized to drive development of postprocedural PTX, but no recommendations have been made to mitigate this. Authors of the current study hypothesized that a low intraprocedural FiO2 might slow absorption atelectasis in the target lobe(s) by preventing rapid nitrogen washout, thereby reducing postprocedural PTX incidence.

Study Design

Study design

- Type of trial: Multicenter before-and-after cohort design
- Study groups: High FiO2 (n = 45) versus low FiO2 (n = 29)
- Setting: Vanderbilt University Medical Center in Nashville, Tennessee, and Saint Luke's Hospital in Kansas City, Missouri
- Enrollment: July 2019 – March 2022
- Treatment period: n/a
- Follow up: 22 months (median)
- Primary outcome: Development of postprocedural PTX, defined as PTX within 2 weeks of EBV placement
- Secondary outcome(s):
    - Time to postprocedural PTX (from bronchoscope removal to first radiographic evidence of PTX)
    - Chest tube duration
    - EBV(s) in place at 6 weeks
    - Treatment response: Complete ATX of target lobe(s), partial ATX of target lobe(s), no ATX

Intervention(s)

- Intraprocedural oxygen saturation of patients undergoing Zephyr EBV placement was managed according to either a high or low FiO2 strategy, depending on whether the procedure occurred before or after adoption of the low FiO2 protocol.
    - High FiO2 protocol: FiO2 maintained per anesthesiologist preference.
    - Low FiO2 protocol: FiO2 reduced to lowest possible concentration to maintain oxygen saturation ≥ 89%.
- In both cohorts, patients were preoxygenated at 100% prior to anesthesia induction.

Population

- Inclusion criteria: Adults undergoing EBV placement for severe emphysema, with all procedural and patient selection protocols unchanged throughout the study period
- Exclusion criteria: n/a
- Baseline characteristics: High FiO2 (n = 45) and low FiO2 (n = 29) cohorts were well-matched in demographic, spirometric, and radiographic characteristics, aside from emphysema distribution (58% heterogenous in the high FiO2 cohort vs 38% in the low FiO2 cohort).
- Procedure characteristics:
    - Mean FiO2 during EBV placement was 0.95 (standard deviation, 0.13) in the high FiO2 cohort vs 0.29 (standard deviation, 0.05) in the low FiO2 cohort.
    - More patients in the high FiO2 cohort underwent placement of an endotracheal tube for the procedure (38 patients [84%] vs 13 [45%]) while more patients in the low FiO2 cohort underwent placement of a laryngeal mask airway (16 patients [55%] vs 7 [16%]).

Outcomes

Primary outcome:

- PTX complicated more procedures in the high FiO2 cohort compared to the low FiO2 cohort (14 [31%] vs 2 [7%], odds ratio 6.1, 95% CI 1.3-29.2, p = 0.01). No variable other than FiO2 was associated with postprocedural PTX development.

Secondary outcomes:

- Time to postprocedural PTX
  - High FiO2 cohort: 6.6 hours
  - Low FiO2 cohort: 81.4 hours
- Chest tube duration
  - High FiO2 cohort: 14 ± 9.8 days
  - Low FiO2 cohort: 3 ± 1.5 days
- EBV in place at 6 weeks
  - High FiO2 cohort: 25 (56%)
  - Low FiO2 cohort: 23 (82%)
- Treatment response in target lobe(s)
  - High FiO2 cohort: complete ATX in 23 (51%), partial ATX in 12 (27%), no ATX in 10 (22%)
  - Low FiO2 cohort: complete ATX in 18 (62%), partial ATX in 4 (14%), no ATX in 7 (24%)

Adverse events: None reported other than PTX and chest tube duration.

Commentary

Strengths

- First study to compare a low intraprocedural FiO2 protocol to routine management in patients undergoing EBV placement
- All EBVs were placed under low FiO2 conditions after the protocol change at each institution, minimizing risk of selection bias
- Well-described and clinically meaningful secondary outcomes; lower rate of PTX in low FiO2 group was associated with shorter chest tube duration and a higher rate of EBVs remaining in place at 6 weeks
- Change in PTX incidence after instituting low FiO2 protocol was consistent across both institutions

Limitations

- Modestly sized before-and-after cohort study, limited by potential bias and unmeasured confounders
- Potentially significant baseline and procedural differences between the two cohorts included percentage with heterogeneous disease, use of ETT vs LMA, and slight changes in procedural and mechanical ventilation duration
- Only Zephyr Pulmonx endobronchial valves used, potentially limiting external validity

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Suggested Reading

Criner GJ, Sue R, Wright S, Dransfield M, Rivas-Perez H, Wiese T, et al. A multicenter randomized controlled trial of zephyr endobronchial valve treatment in heterogeneous emphysema (LIBERATE). Am J Respir Crit Care Med. 2018 Nov 1;198(9):1151–64.

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Article citation

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