

Intraoperative Tidal Volume and Postoperative Oxygenation in Children: A Retrospective Cohort Analysis

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Introduction:

Historically, liberal intraoperative tidal volumes (TV) were used to prevent atelectasis and improve oxygenation. However, this may promote lung injury and hypoxemia secondary to alveolar overdistention, biotrauma and pulmonary edema. While the advantages of low TV ventilation to decrease postoperative lung complications have been demonstrated in adults, evidence in pediatric patients is limited and inconclusive.

Objective:

To determine the association between intraoperative TV and mechanical power (MP) with postoperative oxygenation and postoperative pulmonary complications (PPC) in pediatric patients.

Methods:

- Single-center, retrospective cohort study using electronic data
- **Primary exposure:** Time-weighted average TV per kg of ideal body weight (TWA-TV / IBW)
- **Secondary exposure:** Time-weighted average MP per kg of ideal body weight (TWA-MP / IBW) where $MP = (0.098 \times RR \times TV \times P_{insp})$
- **Primary outcome:** Oxygenation, assessed by repeated measures of SPO₂/FiO₂ during the first postoperative hour in PACU
- **Secondary outcomes:**
 - Repeated measures of SPO₂/FiO₂ during the first 24 hours
 - Composite of serious PPC

Figure 1. Flowchart

1029 surgical cases met inclusion criteria:

- Patients ≤18 years
- Non-cardiac surgery at Cleveland Clinic from 2018 through 2021
- Received general anesthesia with mechanical ventilation using a single lumen endotracheal tube
- Surgery duration ≥ 2 hours
- ASA 1-4
- Required an overnight admission

Exclusion of 564 surgical cases:

- 110 emergent surgeries
- 88 cases with preoperative ICU admission
- 27 cases with oxygen therapy at home, preoperative mechanical ventilation, or preoperative SPO₂ < 90%
- 69 cases surgeries with preoperative congenital cardiac disease or progressive neuromuscular diseases
- 22 cases with postoperative mechanical ventilation
- 207 cases with postoperative ICU admission
- 41 cases missing exposure, outcome, or confounding variables

465 surgical cases from 440 patients for primary analysis

Table 1. Association between intraoperative tidal volume or mechanical power and SpO₂/ FiO₂ during the first hour in the PACU.

Exposure	N	Median [Q1, Q3]	Estimated difference in means in SpO ₂ / FiO ₂ (97.5 % CI)	P value	Exposure-by-age group interaction
TWA of tidal volume per ideal body weight, ml/kg	465	8.1 [7.4, 9.0]	3.54 (-1.29, 8.37)	0.10	0.74
TWA of mechanical power per ideal body weight, × 10 ⁻³ J/min/kg	456	187 [148, 235]	-0.28 (-1.47, 0.90)	0.59	0.75

TWA: Time-weighted average, CI: Confidence interval

Table 2. Association between intraoperative tidal volume or mechanical power and SpO₂/ FiO₂ during the first 24 hours after leaving PACU.

Time-weighted average of tidal volume per ideal body weight (TWA-TV/IBW)			
	N	Estimated difference in means in SpO ₂ / FiO ₂ (97.5% CI)	P value
exposure-by-age group interaction			0.039
Individual age group:	N (%)	Estimated difference in means in SpO ₂ / FiO ₂ (99.38% CI)	P value
Age < 2 years	22 (4.8)	0.098 (-3.31, 3.51)	0.94
2 years ≤ age < 6 years	18 (3.9)	1.47 (-3.64, 6.59)	0.43
6 years ≤ age < 12 years	65 (14)	2.41 (0.84, 3.98)	< 0.0001
12 years ≤ age ≤ 18 years	357 (77)	0.56 (-0.54, 1.67)	0.16

Time-weighted average of mechanical power per ideal body weight (TWA-MP/IBW)			
	N	Estimated difference in means in SpO ₂ / FiO ₂ (97.5% CI)	P value
Overall	453	-0.38 (-0.56, -0.20)	<0.0001
exposure-by-age group interaction			0.35

Results:

First hour in PACU:

- No significant association between TWA-TV / IBW and SPO₂/FiO₂
- No significant association between TWA-MP / IBW and SPO₂/FiO₂

First 24 hours after the patient left the PACU:

- The association between TV and SPO₂/FiO₂ was only significant in the 6-12 years age group.
- An increase TWA of MP was associated with a decrease in SPO₂/FiO₂. Age groups did not modify the association.
- Due to the low incidence of serious PPC (4.5%), we could not assess the association with exposures.

Discussion:

- Intraoperative TV and MP had no impact on oxygenation during the first intraoperative hour.
- In the first 24 hours, the non-significant association between TV and SpO₂/FiO₂ in other age groups may be due to small effect size. despite a significant association in the 6-12 years age group, effect size was small which makes the result fragile.
- The lower Incidence of PPC than previous studies may be possibly due to our inclusion of overall healthier non-cardiac patients.
- Further studies with larger sample size are needed to evaluate age factors and postoperative pulmonary complications.

Conclusion:

In our study, mechanical power, rather than tidal volume, was associated with lower oxygenation during the first postoperative day in children having noncardiac surgery.