



Characterization of Changes in Tracheal Cuff Pressures During General Anesthesia with Nitrous Oxide

UT Southwestern
Medical Center

Ebuka Eziana BS, Girish Joshi MD, Irina Gasanova MD, Asad Khawaja BS, Emmanuel Ogu BSA, Eric Rosero MD MSc.

Background

- Excessive endotracheal tube (ETT) cuff pressure ($>30\text{cm H}_2\text{O}$) is a significant safety concern, as it causes tracheal ischemia and long-term complications like tracheal stenosis.¹
- Nitrous oxide (N_2O) used during general anesthesia (GA) readily diffuses into the ETT cuff, causing a gradual, often unmonitored, increase in intra-cuff pressure in real-world clinical settings.^{2,3}
- The aim of this study was to characterize the changes in ETT cuff pressure over time in adults by continuously monitoring intracuff pressure in adults undergoing general anesthesia with N_2O . Additionally, we investigated the influence of ETT size, airway pressures (PIP and PEEP), N_2O concentration, exposure duration, and patient characteristics such as age, sex, height, and weight.
- By characterizing these patterns, we sought to support a more anticipatory approach to cuff pressure management, as unrecognized overinflation remains a preventable cause of airway injury.

Methods

Inclusion Criteria

- Age > 18 years
- Surgeries requiring GA with N_2O
- Duration of surgeries: 2–6hrs
- ETT sizes 6.0–8.0mm

Exclusion Criteria

- Pre-existing airway abnormalities
- Surgeries requiring insufflation, laser resistant ET tubes.
- Spine, ENT; thoracic surgeries requiring open/one-chest ventilation

System Set-up

- Inflated ETT cuff adjusted to a baseline pressure of $25\text{cmH}_2\text{O}$.
- Transducer zeroed to atmospheric pressure and connected to pilot balloon at tracheal level.

Data acquisition

- Continuous cuff pressure monitoring.
- Data was recorded every 5 minutes using the Philips IntelliVue MX100 monitor.

Cuff pressures were not adjusted perioperatively.

Data analysis

- Collected variables: end-tidal N_2O , PIP, PEEP, ETT size, surgical position, duration, and patient demographics.
- Multilevel mixed-effects linear regression model was used to evaluate changes in cuff pressure.

Results

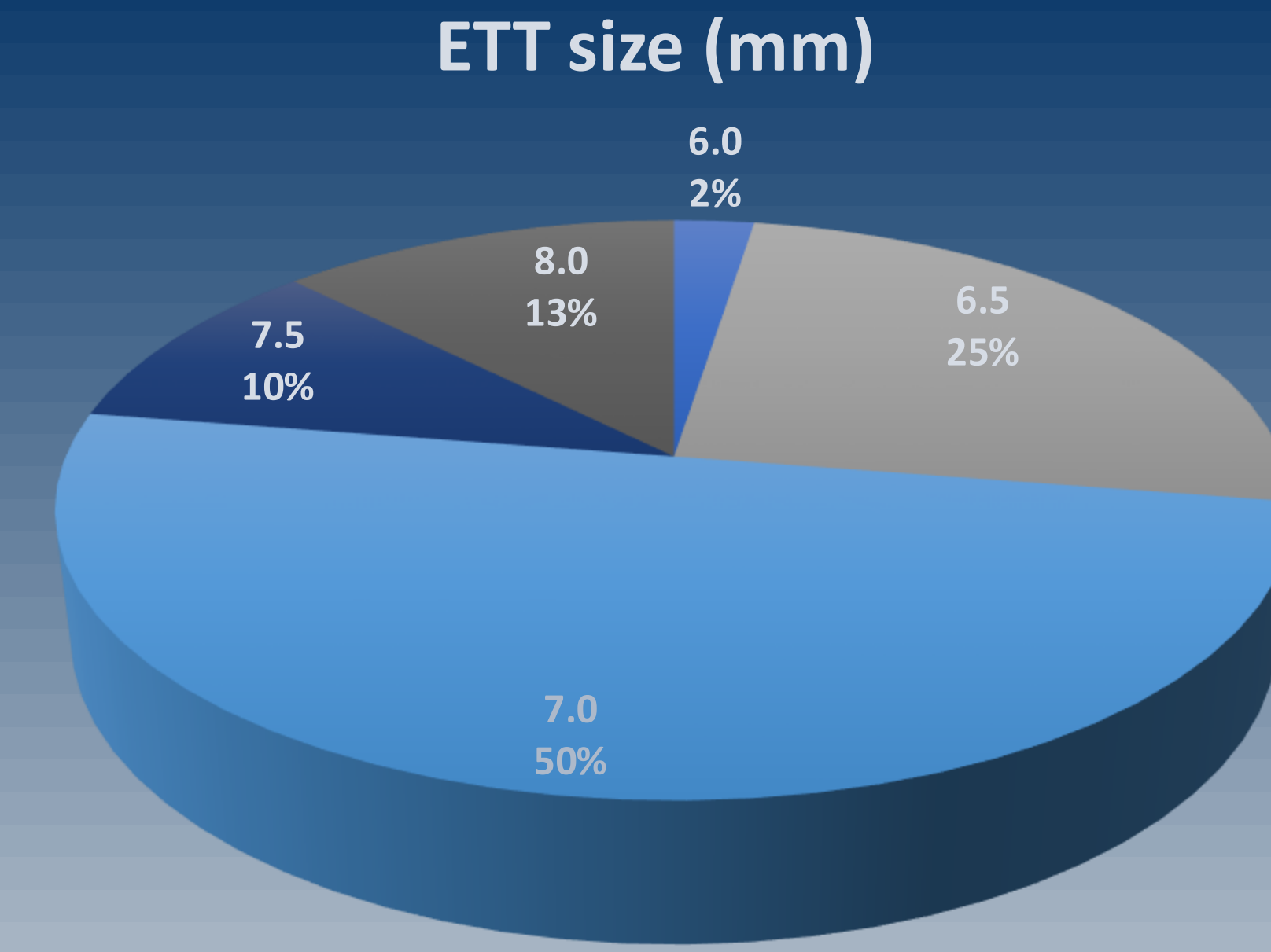


Fig. 2: Distribution of ETT sizes used in the study cohort.

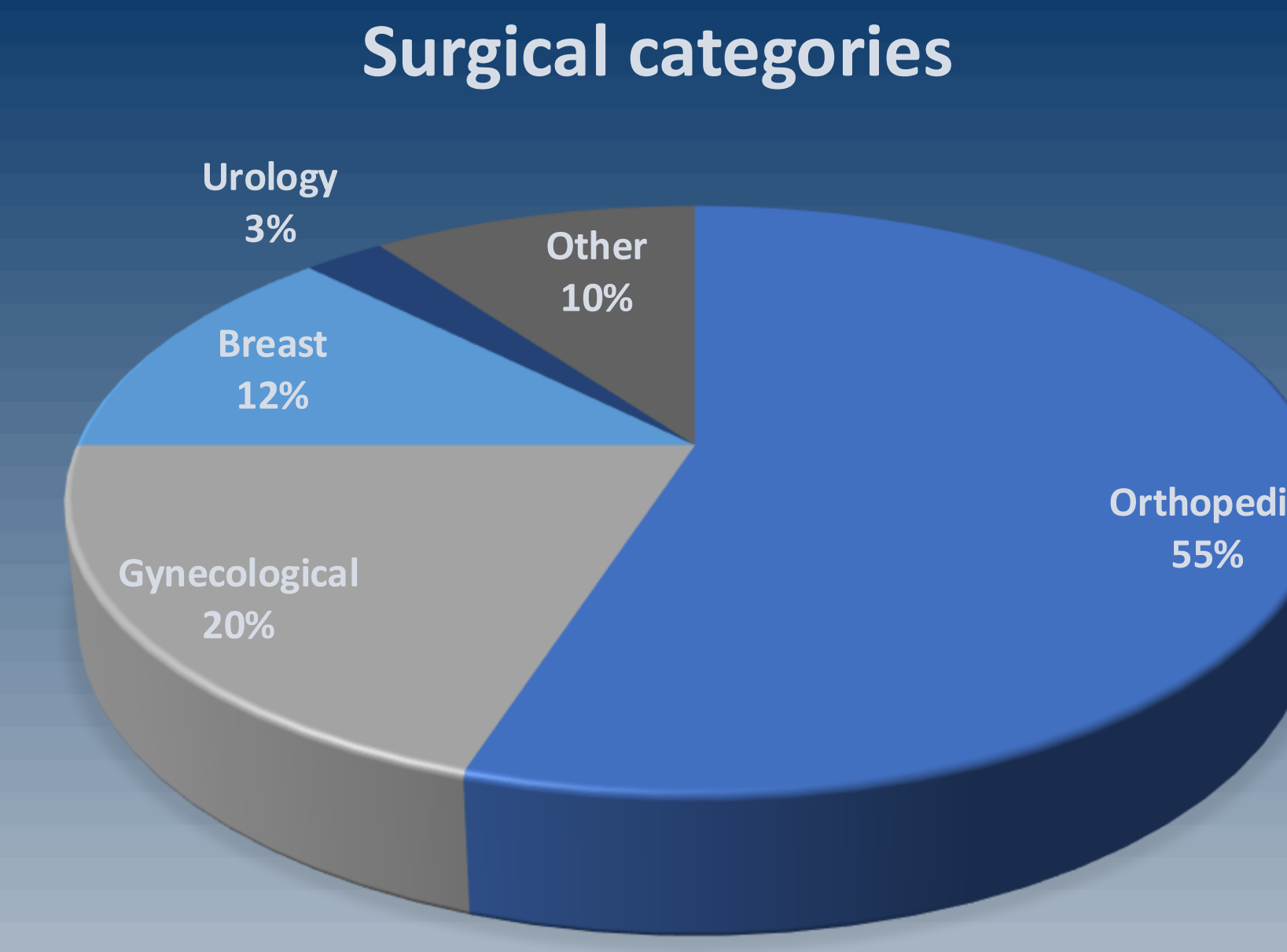


Fig. 3: Distribution of surgical categories among enrolled patients.

Variable	Values
ASA class, n (%)	
1	5 (12.5)
2	18 (45.0)
3	16 (40.0)
4	1 (2.5)
Baseline Tube cuff pressure, cm H_2O , mean (SD)	26.9 (2.6)
Duration N_2O exposure, minutes, median (IQR)	142 (117-177)
Duration N_2O exposure, minutes, range (min-max)	50 - 263
Patient Position	
Supine	35 (87.5%)
Lateral	5 (12.5%)

Table 1. Baseline demographic and anesthetic characteristics of study patients (n = 40)

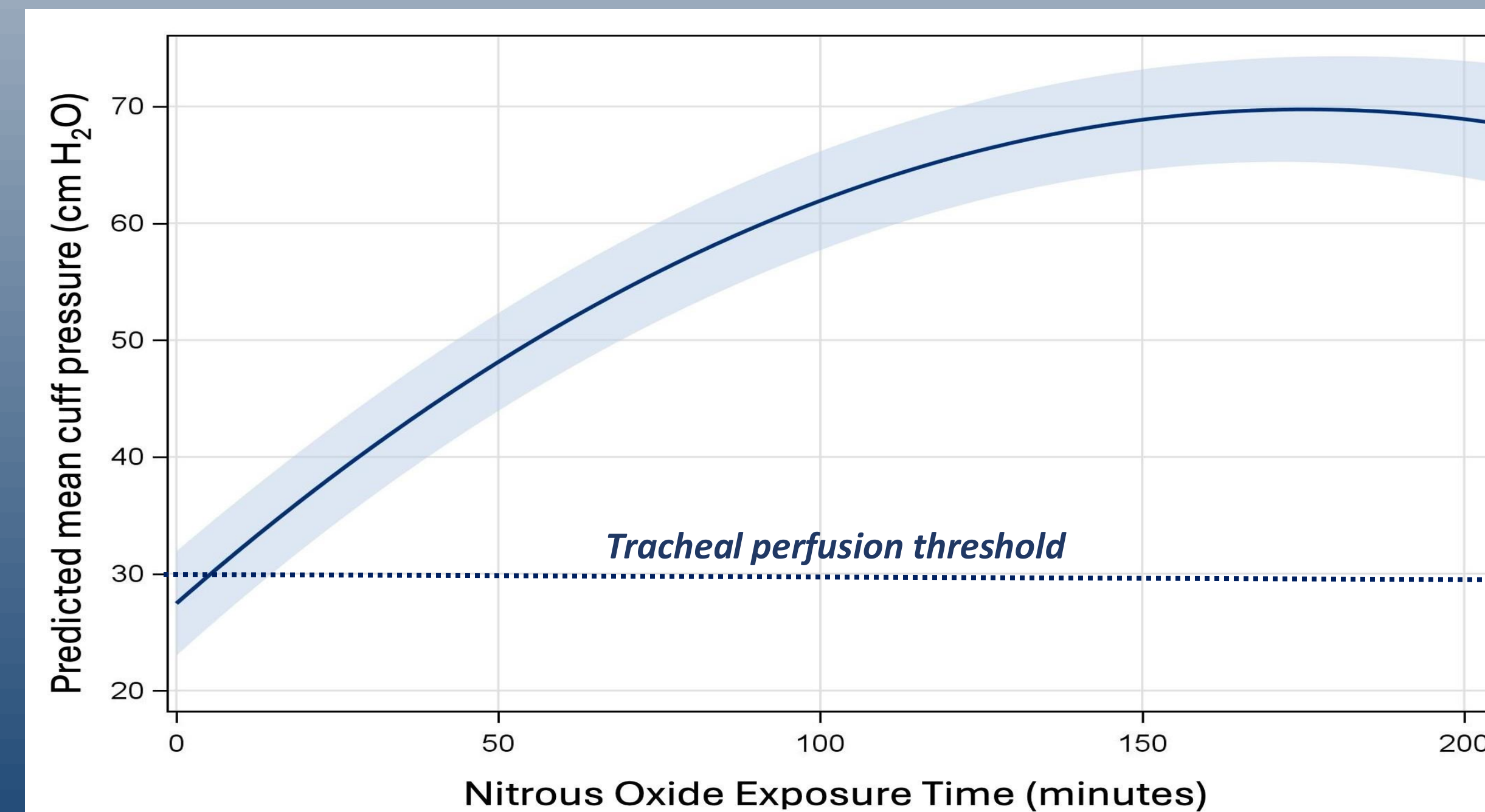


Fig 4: Predicted mean cuff pressure (95% CI) during N_2O anesthesia. The dashed line marks the $30\text{cm H}_2\text{O}$ perfusion threshold

Predictive equation: $\text{Cuff Pressure} = -57 + 0.48 \cdot t - 0.001 \cdot t^2 + 0.13 \cdot [\text{N}_2\text{O}] + 0.21 \cdot h$

Results

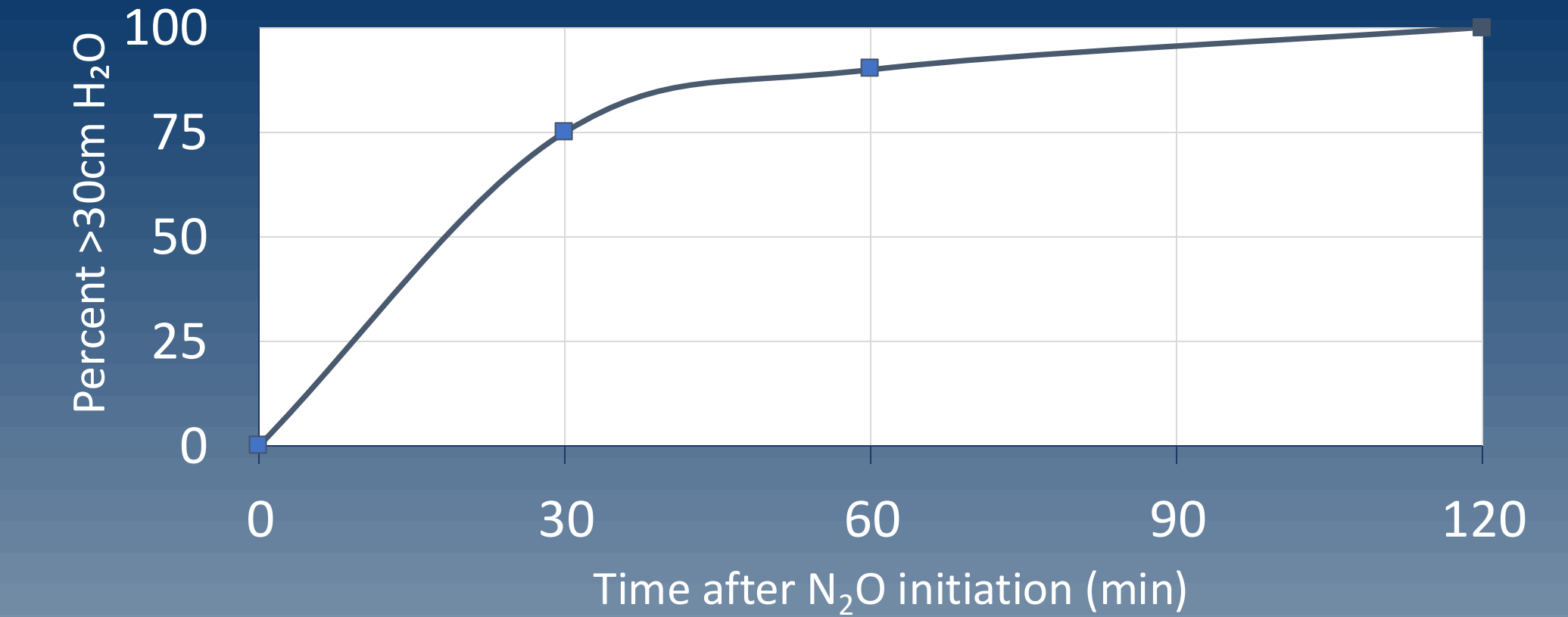


Fig. 5: Percentage of patients with cuff pressure $\geq 30\text{cm H}_2\text{O}$ after N_2O initiation.

- There was a **progressive, non-linear rise** in cuff pressure (Fig. 4). Time (t), N_2O concentration $[\text{N}_2\text{O}]$, and increasing patient height (h) were significant predictors.
- Taller patients (larger tracheal diameter) had higher TTCP**, likely because the larger area of cuff exposed to N_2O , facilitates the diffusion of N_2O into the cuff.
- Cuff pressures rose **rapidly from $25\text{cm H}_2\text{O}$ to $\sim 90\text{cm H}_2\text{O}$ by 120 min**, nearly tripling the tracheal perfusion threshold of $30\text{cm H}_2\text{O}$.⁴
- Notably, **75%** of patients exceeded this limit within the first 30 min (Fig. 5).

Clinical implications

- Cuff pressures frequently exceeded $30\text{cm H}_2\text{O}$ within 30 min of N_2O initiation despite proper baseline inflation.
- Routine quantitative manometer use every ≤ 60 min may offer a practical safeguard from subclinical overinflation.
- Integrating automated or continuous monitoring into anesthesia workstations may enhance safety through real-time pressure alerts and individualized control.

Limitations & Next steps

- Excluded prone, thoracic, and ENT cases; limited representation of extreme body sizes and ETT dimensions restricted subgroup analysis..
- Future studies should validate this predictive model in more diverse operative contexts, e.g., varied patient positioning and airway devices.
- Comparative trials could assess the effectiveness of automated control systems, alarm thresholds, or alternate cuff inflation media.

References

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