

Introduction

- Obstructive sleep apnea (OSA) is characterized by repeated collapse of the airway during sleep resulting in obstruction of airflow, intermittent hypoxia, and transient arousal from sleep.
- For patients with OSA undergoing surgery, specific guidelines as to the optimal general anesthesia approach remain undetermined.
- Both total intravenous anesthesia (TIVA) and volatile gas anesthesia (e.g., sevoflurane) are used as anesthetics in patients with comorbid obstructive sleep apnea (OSA).
- TIVA demonstrates several perioperative benefits including decreased bleeding, operative duration, post-operative nausea and vomiting (PONV), recovery time, post-operative pain score as well as increased patient satisfaction.^{1,2}
- Despite these benefits, TIVA is generally accepted to be a more expensive option in comparison to inhaled anesthetics, and this often limits its widespread use.
- This study aims to compare the total costs of administering TIVA versus inhalational anesthetics during surgeries for OSA.
- A secondary objective of this study was to compare patient time intervals during the day of surgery for patients undergoing TIVA versus inhalational gas anesthesia.

Methods

- A retrospective review was conducted on patients aged 18 and over with sleep study diagnosed OSA receiving surgery for OSA under general anesthesia from January 2019 to October 2020.
 - Surgeries included:
 - Nasal surgery: turbinectomy, septoplasty, open reduction and internal fixation of nasal bone fracture, nasal valve repair, and functional endoscopic sinus surgery (FESS)
 - Upper Airway Stimulation (UAS) with an implantable neuromodulator (Inspire Therapy, Inspire Medical Systems, Minneapolis, Minnesota, USA)
 - Modified uvulopalatopharyngoplasty (UPPP)
- Demographics, comorbidities, cost, and day of surgery time intervals were compared between the two groups (TIVA vs gas anesthesia).

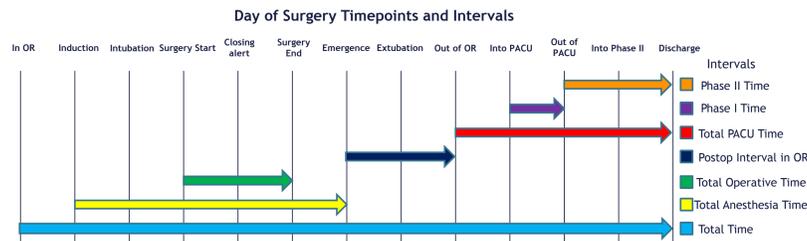


Figure 1. Schematic for calculation of day of surgery timepoints and intervals.

- Costs incurred by the hospital for the provision of care were acquired for the day of surgery for all patients. The following cost categories were obtained:
 - Pharmacy
 - Medical/Surgical Supplies/Devices (Supplies)
 - Operating Room
 - Anesthesia
 - Recovery Room
 - MISC (radiology, labs, etc.)
- The average cost for a UAS implantable device was \$19,962.54 (± \$2,564.07), which was excluded from calculation of Medical/Surgical Supplies/Devices cost.
- Statistical analyses were performed using GraphPad Prism 8. A Mann-Whitney U test was used for unpaired, nonparametric data and a Student's t-test was used for unpaired, parametric data. Binary data were analyzed using the Fischer's exact test. A multivariable model was used to identify factors influencing pharmacy, operating room, anesthesia, and recovery room costs. Statistical significance was defined as P < 0.05.

Results

- Total n=230 patients:
 - 114 nasal surgery, 83 UAS, 33 UPPP
- Patient demographics by anesthetic modality shown in Table 2.
- Demographics were similar between TIVA and gas with respect to age, sex, race, BMI, AHI, and OSA severity.
- *A higher proportion of patients received nasal surgery in the gas cohort compared to the TIVA cohort (56% vs 41%; p = 0.033).

	TIVA (n = 95)	Gas (n = 135)
Demographics		
Age	55.8 ± 11.7 years	53.9 ± 11.6 years
Male:Female	69:26	105:30
BMI	29.8 ± 3.6	30.6 ± 4.6
AHI	30.2 ± 18.6	30.9 ± 19.9
OSA Severity		
% Mild OSA	16% (n = 15)	19% (n = 26)
% Moderate OSA	33% (n = 31)	36% (n = 49)
% Severe OSA	52% (n = 49)	44% (n = 60)
Surgery Received		
Nasal Surgery*	41% (n = 39)	56% (n = 75)
UAS	40% (n = 38)	33% (n = 45)
Modified UPPP	19% (n = 18)	11% (n = 15)

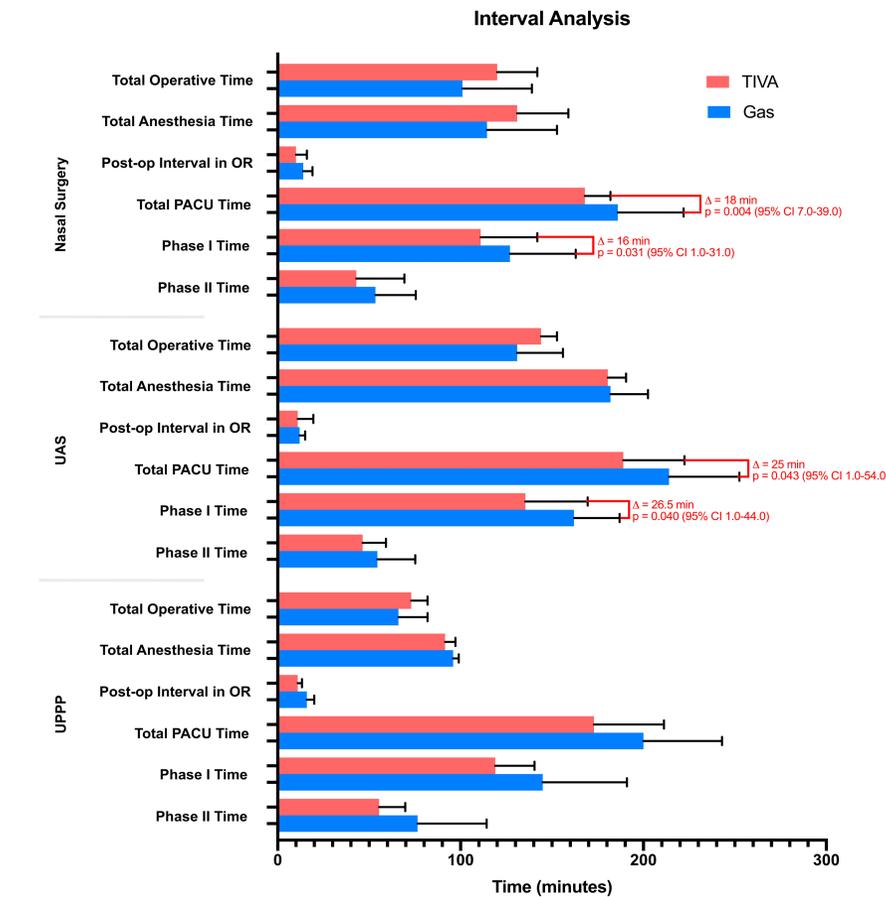


Figure 2. When stratified by type of surgery performed, the TIVA cohort showed a reduction in median Total PACU Time and Phase I Time in patients who underwent nasal surgery and UAS. Patients in the TIVA cohort who underwent nasal surgery had a reduction in median Total PACU Time of 18 minutes (p = 0.004) and a reduction in median Phase I Time of 16 minutes (p = 0.031). Patients in the TIVA cohort who underwent UAS had a reduction in median Total PACU Time of 25 minutes (p = 0.043) and a reduction in median Phase I Time of 26.5 minutes (p = 0.040). While there was a reduction of 27 minutes in median Total PACU Time (p = 0.147) and 26 minutes in median Phase I Time (p = 0.152) for the TIVA cohort who underwent modified UPPP, this did not reach statistical significance, likely due to the smaller sample size.

Mean (±SD)	TIVA (n = 95)	Gas (n = 135)	Δ	P-value
Nasal Surgery (n = 114)				
Pharmacy	\$367.40 (±116.45)	\$198.94 (±87.16)	+\$168.45	< 0.001
Supplies	\$538.07 (±224.30)	\$610.45 (±385.29)	-\$72.38	0.208
Operating Room	\$1,476.57 (±427.98)	\$1,189.77 (±321.40)	+\$286.81	< 0.001
Anesthesia	\$79.69 (±80.28)	\$116.36 (±118.70)	-\$36.67	0.054
Recovery Room	\$575.36 (±163.14)	\$639.81 (±243.16)	-\$64.45	0.096
MISC	\$11.87 (±29.84)	\$7.60 (±23.06)	+\$4.30	0.439
Total	\$3,048.94 (±649.69)	\$2,762.92 (±718.73)	+\$286.03	0.035
UAS (n = 83)				
Pharmacy	\$352.04 (±112.84)	\$185.95 (±125.70)	+\$166.09	< 0.001
Supplies	\$1,491.06 (±607.74)	\$1,910.56 (±774.91)	-\$419.50	0.007
Operating Room	\$1,897.89 (±286.71)	\$1,629.53 (±254.66)	+\$268.36	< 0.001
Anesthesia	\$89.72 (±98.58)	\$90.80 (±86.79)	-\$1.08	0.958
Recovery Room	\$660.81 (±236.21)	\$771.90 (±300.24)	-\$111.09	0.063
MISC	\$70.08 (±17.74)	\$65.43 (±17.57)	+\$4.65	0.180
Total	\$4,561.60 (±626.10)	\$4,654.17 (±859.66)	-\$92.57	0.573
UPPP (n = 33)				
Pharmacy	\$306.24 (±66.50)	\$148.05 (±49.47)	+\$158.19	< 0.001
Supplies	\$150.06 (±22.43)	\$305.22 (±216.79)	-\$155.16	0.015
Operating Room	\$1,071.07 (±185.37)	\$888.32 (±193.17)	+\$182.75	0.010
Anesthesia	\$75.93 (±39.40)	\$109.92 (±77.33)	-\$33.99	0.138
Recovery Room	\$617.14 (±168.85)	\$728.26 (±486.73)	-\$111.12	0.411
MISC	\$73.86 (±25.81)	\$77.88 (±17.98)	-\$4.02	0.603
Total	\$2,294.29 (±200.42)	\$2,257.65 (±572.44)	+\$36.64	0.816

- TIVA produced significantly higher Pharmacy and Operating Room costs in all groups.
 - For UAS and UPPP, these increased costs were offset by significantly lower Medical/Surgical Supplies/Devices costs in the TIVA cohort.
- In the TIVA nasal surgery cohort, there was a trend toward lower Anesthesia and Recovery Room costs.
- In the TIVA UAS cohort, there was a trend toward lower Recover Room costs.
- Total Cost was significantly higher in the nasal surgery group that received TIVA vs Gas by \$286.
- There was no significant difference in Total Cost between TIVA and Gas for UAS or UPPP.
- On multivariable analysis, increased OSA severity, male sex, and higher ASA score were associated with increased total cost.
- Between the TIVA and gas cohorts, there was no significant difference in post-operative nausea and vomiting (p = 0.192) or post-operative complications.

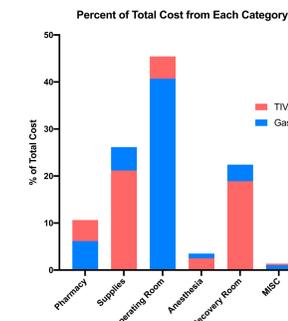


Figure 3. Superimposed graphs demonstrating the breakdown of total cost in the TIVA vs Gas cohorts. TIVA has a higher percent of total cost coming from Pharmacy and Operating Room costs. Gas has a higher percent of total cost coming from Supply and Recovery Room costs.

Conclusion

- Our group previously reported decreased recovery times for patients with OSA undergoing airway surgery with TIVA versus gas anesthesia. We found a similar trend in this study.
- When used in an outpatient surgery center for patients with OSA, TIVA adds to Pharmacy and Operating Room costs, but this is usually offset by lower Supply, Anesthesia, and Recovery Room costs.
- TIVA resulted in higher total cost in the nasal surgery group. Total cost did not differ between TIVA and Gas for patients undergoing UAS or UPPP. This suggests variation in cost effectiveness by type of surgery.
- We believe that, while cost data may vary somewhat between institutions, our description provides strong evidence for the financial feasibility of TIVA for routine use.

References

- Schraag S, Pradelli L, Alsaleh AJ et al. Propofol vs. inhalational agents to maintain general anaesthesia in ambulatory and in-patient surgery: a systematic review and meta-analysis. BMC anaesthesiology 2018; 18:162.
- Kumar G, Stendall C, Mistry R, Gurusamy K, Walker D. A comparison of total intravenous anaesthesia using propofol with sevoflurane or desflurane in ambulatory surgery: systematic review and meta-analysis. Anaesthesia 2014; 69:1138-1150.