

# Earlier Detection of Respiratory Depression in Sedated Patients by Using a Tracheal Sound Monitor

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## Introduction

Clinical guidelines [1, 2] recommend that the ventilation of a patient who receives intravenous general anesthesia (IVGA) should be monitored by capnography or tracheal auscultation, and the blood oxygen level should be monitored by a pulse oximeter. However, oxygen desaturation is a delayed response to hypoventilation, which is shown by previous studies [3]. In this study, we aimed to reproduce the results by using a self-developed tracheal sound monitor, and thus validated the effectiveness of the monitor.

## Materials and Methods

A total of 77 patients underwent a surgical procedure that needed IVGA. A tracheal sound monitor and pulse oximetry were used to monitor the patients. The protocol was reviewed and agreed by En Chu Kong Hospital (case number: ECKIRB1090303). The tracheal sound monitor consisted of an electronic stethoscope (AccurSound AS-101, Heroic Faith Medical Science Co., Ltd., Taipei, Taiwan) connected to a smartphone (Mi 9T pro, Xiaomi, Beijing, China) with a self-developed respiratory sound monitoring app installed. 53 sedative procedures were completed by Dr. One, 12 by Dr. Two, and the other 12 by Dr. Three. A researcher was asked to record partial airway obstruction (PAO), total airway obstruction (TAO), apnea, and oxygen desaturation ( $SpO_2 < 95$ ) events when she identified them using the tracheal sound monitor and pulse oximetry. The anesthesiologists were blind to the tracheal sound monitor. However, the anesthesiologists were asked to immediately report the PAO, TAO, and apnea events they identified to the researcher. The anesthesiologists were free to do all treatments or maneuvers if they saw fit or not to.

## Results

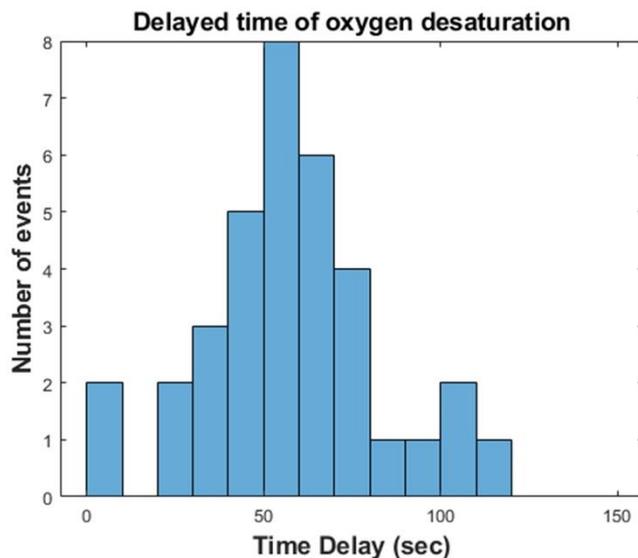
Fig 1 displays that there were 53 PAO, 2 TAO, and 132 apnea events recorded by the researcher. The anesthesiologist did not identify 3 of the PAO, 1 of the TAO, and 31 of the apnea events before the oxygen saturation dropped under 95%. Fig 2 displays the distribution of time delay between the oxygen desaturation and the respiratory events identified by the researcher using the tracheal sound monitor. The mean time delay was  $56.86 \pm 24.80$  seconds.

### Discussion

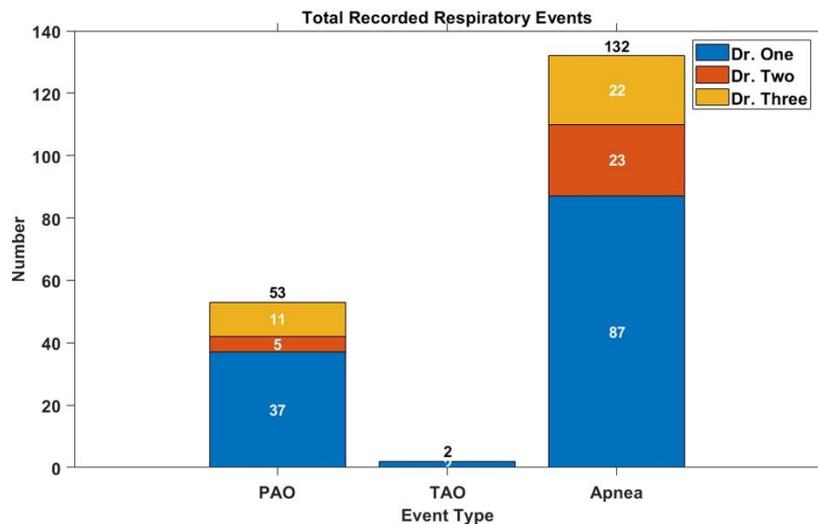
The results showed that the researcher can successfully identify PAO, TAO, and apnea by using the self-developed tracheal sound monitor, which were on average 56.86 seconds earlier than the eventually developed oxygen desaturation. This study validates the tracheal sound monitor in the use of ventilation monitoring. Automated PAO, TAO, and apnea detection algorithms could be developed in the future to make the tracheal sound monitor more powerful and valuable.

### References

- [1] A. D. Association, "Guidelines for the use of sedation and general anesthesia by dentists," *Adopted by the ADA House of Delegates*, 2016.
- [2] S. S. S. Lives, "WHO guidelines for safe surgery 2009," *Geneva: World Health Organization*, 2009.
- [3] Cacho, G., et al. "Capnography is superior to pulse oximetry for the detection of respiratory depression during colonoscopy." *Revista espanola de enfermedades digestivas* 102.2 (2010): 86.



**Figure 2. Distribution of delayed time between the oxygen desaturation and the identified respiratory events.** Mean value of delayed time was  $56.86 \pm 24.80$  seconds.



**Figure 1.** The number of PAO, TAO, and apnea events recorded by the researcher by using the tracheal sound monitor during the sedative procedures performed by the three different anesthesiologists. PAO: partial airway obstruction. TAO: total airway obstruction.