

Detection of Fresh Gas Leakage During Induction and Emergence

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Introduction. “Sonifications” are auditory displays that convey the patient’s vital signs information to the anesthesiologist as continuous sounds¹. The audible pulse oximetry tone is the most widely used sonification. Researchers have attempted to extend this concept to other physiological variables, such as respiratory rate and tidal volume²⁻⁵. During clinical testing of a sonification, we discovered that the fresh gas leaking out of the breathing circuit during induction and emergence was being unexpectedly sonified as a large inspiration – producing a loud and uninformative sound. We developed an algorithm to address this by detecting the patient’s breathing state using spirometry data only from the ventilator.

Methods. Respiratory data was recorded during 25 surgical cases at the Royal Adelaide Hospital with patients undergoing general anesthesia. Airway pressure and flow waveforms were captured from Datex-Ohmeda Aestiva/5 ventilators in 16 millisecond samples. An offline algorithm implemented in Matlab classified the ventilator’s behavior into one of four states: inspiration, expiration, no breathing, and fresh gas leakage. An inspired/expired volume waveform (required for the Sanderson & Watson sonification⁴⁻⁵) was constructed from the flow waveform and breathing state classification.

Results. An example of the breathing state classification and volume waveform is shown in Figure 1. The patient is initially pre-oxygenated through the anesthesia circuit (Figure 1a), after which the mask is removed for intubation. During intubation, fresh gas leaks out of the mask and was originally incorrectly classified as a large inspiration (Figure 1b). Our algorithm detects the leak (Figure 1c) and zeroes the volume waveform (Figure 1d). Sudden movements of the mask, however, create artifacts in the flow and pressure waveforms and are misinterpreted as inspiration (Figure 1e). During mechanical ventilation, the breathing states return to normal cycles of inspiration and expiration (Figure 1f).

Discussion. Our algorithm eliminates the fresh gas leakage problem with sonification during the induction and emergence phases of anesthesia. Future work includes adapting the algorithm for real-time classification, validating the accuracy of the algorithm, and implementing a sonification that uses the algorithm in the clinical environment.

References:

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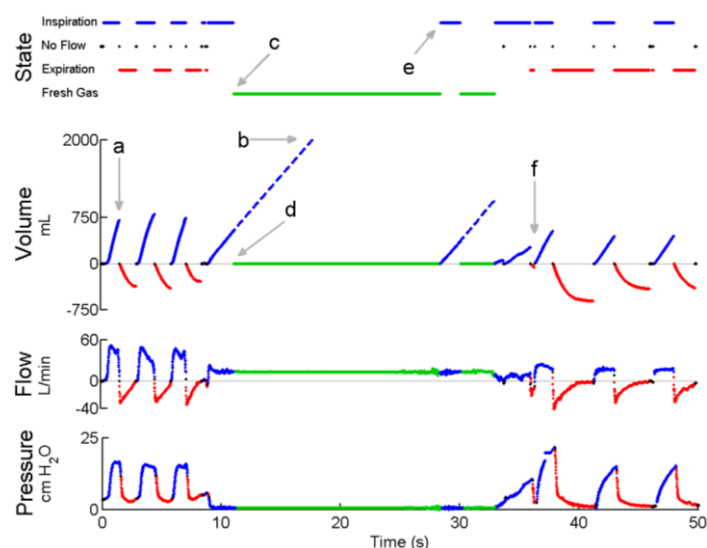


Figure 1 Example of airway data captured from the ventilator during induction of general anesthesia: (a) spontaneous ventilation for pre-oxygenation, (d) apnea during intubation, (f) mechanical ventilation.