

# APNEA DETECTION DURING SEDATION USING TRACHEAL SOUNDS ENTROPY

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**Introduction:** Undetected apnea can lead to hypoxic encephalopathy, bradycardia and even cardiac arrest. Tracheal sounds entropy has been proved to be a robust method for estimating respiratory flow,(1) thus maybe a more reliable way to detect apnea. Our study hypothesis is that changes in the entropy of tracheal sounds will provide an early warning of the onset of apnea in sedated patients, especially when the patients receive supplemental oxygen.

**Method:** After obtaining IRB approval, 24 volunteers received propofol and remifentanyl in graded steps until they became unresponsive to the insertion of a bougie into the trachea (simulating an endoscope). At each step, respiratory flow rate and tracheal sounds were recorded using a pneumotachometer (CO2SMO, Novamatrix, Louisville, KY) and a microphone (WM-56A103 Panasonic) placed in a precordial stethoscope. The logarithm of the tracheal sound Shannon entropy (Log-E) was calculated to estimate flow rate. An adaptive Log-E threshold was used to distinguish between the presence of normal breath sounds and apnea. Apnea detected from breath sounds was compared to the apnea detected from respiratory flow rate, Fig 1.

**Result:** Apnea occurred 322 times during the 12.9 hr study. Table 1 shows that the volunteers did not breathing for 15 sec or longer (apnea) for a total of 148 min, as detected from both the tracheal sounds and the respiratory flow meter. Periods of apnea were not detected by the tracheal sounds for a total of 7 min. Tracheal sounds misclassified periods of normal breathing as apnea for a total of 54 min. The acoustic method detected apnea in sedated volunteers with a sensitivity of 95% and a specificity of 91%.

**Discussion:** We found the entropy of the acoustic signal from a microphone placed over the trachea may reliably provide an early warning of the onset of apnea in volunteers receiving propofol and remifentanal.

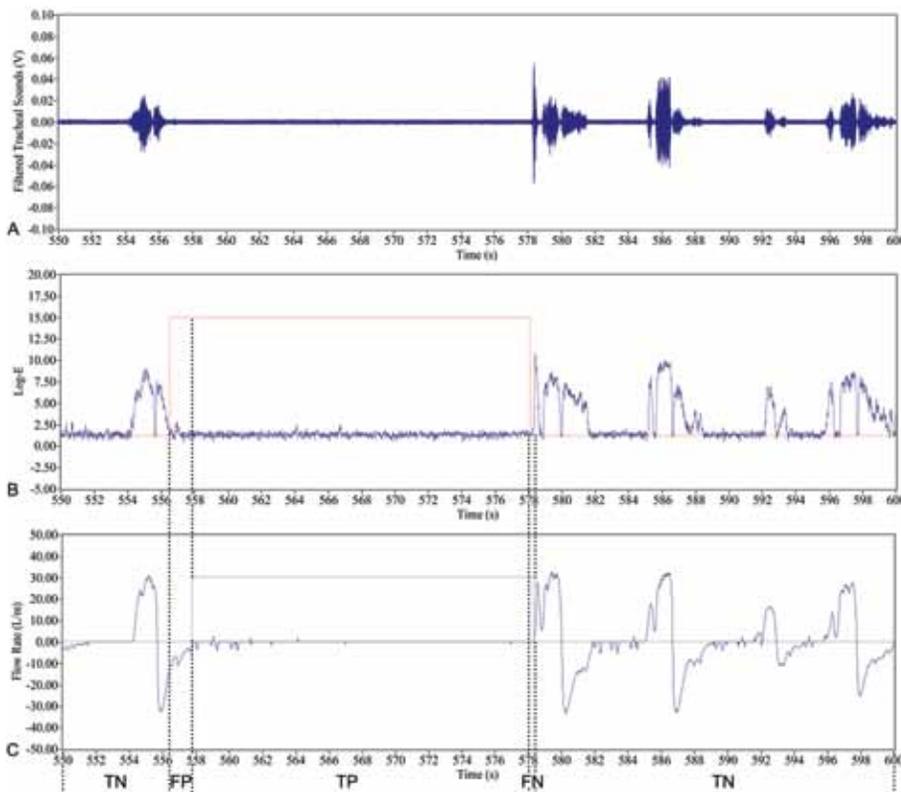


Fig 1. Tracheal sounds before and after a period of apnea (A), Log-E signal where the period of apnea is shown by the red line (B) and respiratory flow rate where the period of apnea is shown by the green line (C).

	Flow Meter	
Tracheal sounds	Apnea	Normal
Apnea	148 min (TP)	54 min (FP)
Normal	7 min (FN)	565 min (TN)

Table 1. The total sum of the length of all apneic periods, as detected from tracheal sounds and respiratory flow.

## References

1. Yadollahi A, Moussavi ZM. A robust method for estimating respiratory flow using tracheal sounds entropy. IEEE Trans Biomed Eng 2006;53:662-8.