

# Discord in the Definition of Apnea: An Analysis of Apnea Duration in Sedated Volunteers

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**Introduction:** Studies from John Hopkins and the University of Utah have shown apnea alarms are either ignored or incorrect as much as 90% of the time in the clinical setting. Looking at apnea-related studies, there appears to be a lack of consensus about the definition of ‘apnea’. The literature cites acceptable apnea definitions between ten and twenty seconds since the last breath. The FDA acknowledges ‘type 1’ apnea as lasting ten to twenty seconds while ‘type 2’ apnea lasts more than twenty seconds. Among commercial clinical monitors, most alarms allow the physician to set the alarm within the ten to sixty second range. Given the statistics on reported false-positives and ignored alarms, one must wonder which of these definitions, if any, is ‘correct’ or at least clinically significant. We studied the length of time between breaths in healthy volunteers receiving target controlled infusions of sedatives and hypnotics to learn whether a clear cutoff is evident between hypoventilation and apnea.

**Methods:** With IRB approval, fifteen healthy volunteers (Ages 19-41, BMI 20.9-28.4) were administered target-controlled infusions of Remifentanyl (0.75-5 ng/mL) and Propofol (1 ng/mL) to achieve increasing levels of sedation and induce apnea, hypopnea, and airway obstruction—both individually and in combination. At each level of sedation, the modified observer’s assessment of alertness and sedation (OAA/S) and the respiratory rate were recorded. The OAA/S scores the level of sedation on a scale of 5 (awake) to 0 (unresponsive). In order to evaluate specific ‘time since last breath’ apnea definitions, each interbreath interval was placed in a histogram using a bin width of one second (figure 1).

**Results:** Twenty-five hours of data were obtained (9403 breaths). Sedated subjects reached every OAA/S score from zero to five. The histogram produced from these data approximates most closely to an inverse Gaussian distribution with  $\mu=9.58$  and  $\lambda=14.10$ . 66% of interbreath intervals were ten seconds or less and 90 and 95% of intervals were 20 and 25 seconds or less, respectively.

**Conclusion:** Most post-operative patients receive opioids for pain relief, so this data set should correlate especially well with what we would expect to see in the postoperative period. As an indicator of respiratory distress (i.e. apnea), a ten second interbreath interval appears too short. In fact, there does not appear to be any clearly identifiable cutoff that defines apnea. Based on a percentile approach, an interbreath interval of at least a twenty seconds would seem most fitting for an apnea alarm. However, merely looking at time since the last breath and ignoring tidal volume or the number of breaths observed in the last minute will likely lead to a large number of false positive alarms and alarm fatigue. A comparison with other variables, such as  $etCO_2$ , may be required in order to define clinically significant alarms.

