A Comparison of Finger, Ear and Forehead SpO2 on Detecting Oxygen Desaturation in Healthy Volunteers.

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Introduction

Pulse oximetry, continuous noninvasive monitoring of arterial hemoglobin saturation (SpO2), has become a standard tool for preventing and detecting hypoxia. SpO2 sensor is usually placed on a peripheral digit, however under certain conditions, e.g. peripheral vasoconstriction, reliability is diminished. Forehead reflectance SpO2 claims to provide more reliable values under such conditions than finger SpO2. However, forehead SpO2 has some reported limitations, such as, during head-down position or positive pressure ventilation which elevate venous pressure. Therefore, it has been reported that forehead SpO2 should be applied with elastic head band so that venous pulsation artifacts do not affect SpO2 values [1]. Under three positions, i.e. head-down (-15°), supine (0°) and head-up (+15°) positions, we compared the performance on detecting hypoxia of SpO2 sensors placed on finger, as a standard, compared with both forehead using head band or with ear sensors.

Method

Eight healthy male volunteers between 25 and 45 years of age were enrolled after obtaining informed consent. The Nellcor forehead sensor (MaxFast), the MASIMO® ear sensor (TC-I) and the MASIMO® finger sensor (LNOP) were attached to the appropriate sites. To observe the change of SpO2 values, we instructed volunteers to take a deep breath, and then to keep holding breath as long as possible. The same process was repeated under head down, supine and head-up positions. The averaging time of SpO2 was set, when possible, at 2 seconds. We deleted data if the minimum SpO2 values were not less than 90%. We recorded the pulse oximetry-related data with computers every second. Data were analyzed using Kruskal - Wallis tests or Wilcoxon signed-ranks tests.

Results

Observed SpO_2 and time for desaturation and for upturn under three positions

Position	SpO_2 Site	Control SpO_2 (%)	Minimum SpO_2 (%)	Time for desaturation (sec)	Time for upturn (sec)
Head-down	Finger	98.4 ± 0.9 *	82.5 ± 5.7	122.4 ± 42.6	17.2 ± 6.2
	Forehead	99.4 ± 0.8	82.8 ± 5.5	111.9 ± 43.4 †	9.6 ± 3.2 ‡
	Ear	98.2 ± 1.5	82.4 ± 4.1	112.6 ± 41.1 ‡	10.5 ± 2.2 ‡
Supine	Finger	98.6 ± 1.3	79.8 ± 5.8	137.9 ± 51.3	18.8 ± 4.2
	Forehead	99.3 ± 1.1	81.9 ± 4.5	134.7 ± 49.2	10.3 ± 2.5 ‡
	Ear	98.6 ± 1.1	80.7 ± 4.0	131.0 ± 51.3 †	10.5 ± 2.1 ‡
Head-up	Finger	98.3 ± 1.4 *	75.7 ± 9.7	142.6 ± 46.2	19.5 ± 5.0
	Forehead	99.2 ± 1.2	78.1 ± 8.6	136.4 ± 44.9	10.6 ± 3.3 ‡
	Ear	98.2 ± 1.1	76.6 ± 8.3	133.8 ± 47.2 †	9.7 ± 3.3 ‡

Data are expressed as mean ± SD. * $P < 0.05$ compared with each other. † $P < 0.05$ and ‡ $P < 0.01$, compared with the finger SpO_2 at each positions. Time for desaturation is the intervals from the beginning of breath-holding to SpO_2 declining below 90%. Time for upturn is the intervals from the end of breath holding to SpO_2 exceeding minimum value.

Conclusion

Although the influence of increased intra-thoracic pressure due to holding breath is unknown, under these three positions our results suggest that; 1) Sensors on the head (forehead and ear), especially Masimo ear sensor, can detect hypoxia as soon as or even sooner than finger and; 2) Sensors on the head (forehead and ear) can also sense recovery state from hypoxia sooner than finger.

[1] Agashe et al. Anesthesiology 2006; 105: 1111-1116.