"Motion-Resistant" Pulse Oximetry: A Comparison of New and Old Models

Barker SJ. *Anesthesia and Analgesia* 2002;95:967-72

Introduction

In previous studies, this researcher compared the performance of several pulse oximeters during mechanically controlled persistent motion and hypoxemia.[1,2] In this study, using the same test protocol, he studied all commercially available motion resistant pulse oximeters along with numerous conventional pulse oximeters during reduced perfusion and mechanically controlled motion (both periodic and random) on volunteers breathing room air and hypoxic gas mixtures.

Methods

Seventy (70) healthy volunteers participated in this study, with IRB approval and informed consent. Each subject was monitored with 6 oximeter sensors: three on digits 2,3, and 4 of the moving "test" hand and 3 of the same make and model on the digits of the non-moving "control" hand. The room temperature was reduced to 16º - 18º C to decrease peripheral perfusion. The test hand motions were achieved in a standardized, repeatable fashion by a computer-driven motion table. Tapping and rubbing motions at both fixed and randomly varied frequencies were studied. Data were recorded during various motions while subjects breathed room air, and during rapid arterial desaturation to SpO_2 ~ 75%. During the room air studies, 2 minutes of data were recorded for 2 motions: 1) fingers tapping at 3 Hz or at a frequency that varied randomly between 1 and 3 Hz and 2) fingers rubbing at these same frequencies. Once the two motions were completed and all SpO_2 values returned to baseline, the sensors were moved to different test fingers and the series was repeated twice, so that all 3 test digits were monitored with each test pulse oximeter. The protocol during hypoxemia included the addition feature of disconnecting and reconnecting (DC/RC) all test sensors after the motion had begun. The hypoxemia series was as follows: 1) non-motion hypoxemia to assess differences in instrument, limb, and finger response times; 2) random tapping motion with DC/RC at start of hypoxemia; 3) 3 Hz tapping motion with DC/RC at start of hypoxemia; 4) 3 Hz tapping during hypoxemia; and 5) random rubbing without DC/RC during hypoxemia. This series was performed once with each subject. Test and control SpO_2 values were compared in terms of sensitivity and specificity. Sensitivity measured a pulse oximeter's ability to detect a true desaturation, and specificity measured the pulse oximeter's likelihood of not generating false alarms during motion. An SpO_2 of 90% was chosen as the low alarm threshold. An SpO_2 performance index (PI) and pulse rate performance index along with drop out rate were calculated for each pulse oximeter. The SpO_2 PI measured the percentage of total time the displayed SpO_2 was within 7% of the control, and the PR PI measured the percentage of total time the pulse rate was within 10% of the control. The drop out % measured the total time the SpO_2 displayed was either zero or dashes.

Author's Discussion and Conclusion

"In summary, our volunteer data provide strong evidence that newer-generation pulse oximeters exhibit improved performance during patient motion. In particular, the Masimo SET appears to provide superior performance during patient motion, with substantially higher values of PI, sensitivity, and specificity." "The clinical implications of this performance improvement are significant. Because awake, hypoxic patients tend to be agitated and moving, pulse oximeters are more likely to be affected by motion artifact when the patient is in distress. Motion-resistant or read-through-motion oximeters, particularity the Masimo, will be more capable of displaying accurate SpO_2 values in this setting, which will improve our ability to detect life-threatening hypoxemia."

1. Barker SJ, Shah NK. The effects of motion on the performance of pulse oximeters in volunteers. *Anesthesiology* 1997;86(1):101-108
2. Barker SJ. The performance of six "motion-resistant" pulse oximeters during motion, hypoxemia, and low perfusion in volunteers. *Anesthesiology* 2001;95:A587

Results

Pulse oximeter	SpO_2 Performance Index	Pulse Rate Performance Index	SpO_2 sensitivity	SpO_2 specificity	Dropout rate (%)	Bias (%)	Precision (%)
Masimo SET® (v2)*	94	85	98	93	0.2	-0.41	2.98
Philips Viridia 24 C (Rev B.0)*	84	75	78	90	1.6	-1.52	4.51
Philips CMS (Rev B.0)*	80	73	70	83	3.7	-1.87	5.96
Datex-Ohmeda 3740	80	11	68	80	0.0	-2.33	4.20
Datex-Ohmeda 3800	79	12	63	77	0.7	-2.24	4.17
Datex-Ohmeda AS/3	77	67	90	45	0.2	-3.73	5.30
Nellcor N-395 (v 1620)*	71	47	66	78	4.1	-3.17	5.44
Datex-Ohmeda 3900	68	12	60	52	1.0	-3.20	4.22
Novametrix MARS (2000-10)*	58	27	40	42	2.4	-4.42	5.39
Hewlett-Packard CMS	57	20	63	30	0.5	-8.52	7.11
Nellcor N-180	57	15	35	43	3.1	-5.90	5.95
Marquette 8000	55	27	40	45	0.2	-6.22	6.68
Nellcor NPB-295	55	16	39	53	8.0	-5.79	6.21
Novametrix 520A	54	11	35	30	0.7	-5.03	5.07
Nellcor N-200	53	19	53	43	0.8	-7.18	5.97
BCI 3304	53	10	28	25	1.2	-7.38	5.74
Nonin 8600	48	13	45	18	1.4	-6.19	5.67
SpaceLabs 90308	46	40	40	23	0.8	-9.50	6.89
Nellcor NPB-190	43	16	48	33	11.1	-9.41	6.07
Criticare 5040	27	5	30	15	5.4	-12.64	6.44

* indicates pulse oximeters, which claim "motion resistance"

Table 1. Pulse oximeters are listed in descending order of SpO_2 performance index, which is the percentage of time the pulse oximeter displays an SpO_2 within 7% of control.

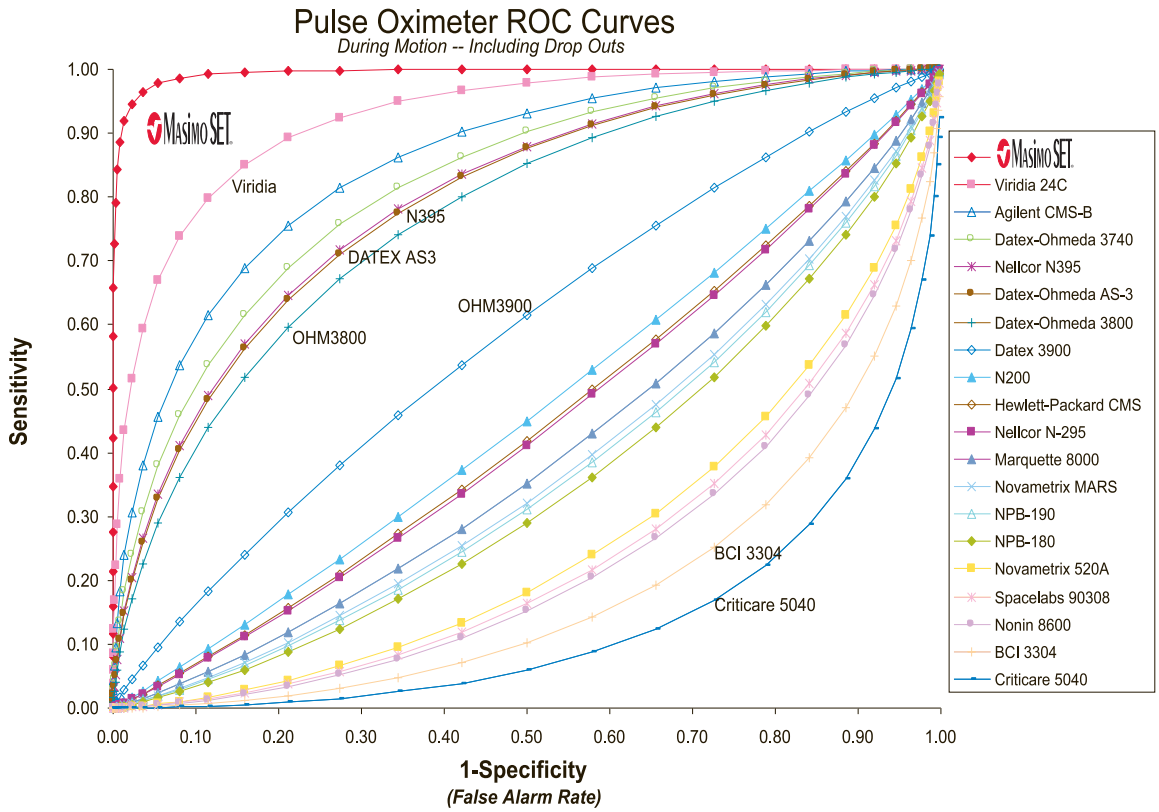

Figure 1. Receiver operating characteristic (ROC) curves calculated for 20 pulse oximeters in this study. The best-performance ROC curves lie in the upper left corner. Diagnosis of hypoxemia by a coin toss would produce an ROC curve along the line of identity, x=y.