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

Barker SJ. The effects of motion and hypoxemia upon the accuracy of 20 pulse oximeters in human volunteers. *Sleep & Sleep Disorders Research* 2001;24:A406

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Barker SJ. *Anesthesia and Analgesia* 2002;94(S1):S17-S20

Introduction

In previous studies, this researcher compared the performance of pulse oximeters during mechanically controlled persistent motion and hypoxemia. In this study, using the same test protocol, he researched the performance of 20 pulse oximeters, including all major brands of commercially available motion resistant 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 the study. To simulate low perfusion, the room was cooled (16-18°) until the majority of the subjects' perfusion was less than normal (< 0.8% arterial pulse strength compared to DC-non pulsating signal). The authors had used other modes of reducing perfusion, such as occlusion of the arterial blood to be not as good of a model.

Each volunteer was instrumented with pulse oximeter sensors; three on the non-moving “control” hand, and three on the moving “test” hand because the pinky and the thumb do not experience the same motion or perfusion as the other fingers. In all trials, a Masimo SET pulse oximeter was compared with two other pulse oximeters. A computer-controlled motorized motion device produced persistent and repeatable tapping and rubbing motions from one subject to the next. Measurements of SpO_2 were made while the subjects breathed room air as well as, during quick desaturations to approximately 75% to 80% and resaturation back to baseline. SpO_2 values during motion on the test hand were compared with values from the control hand. The motions were persistent through the desaturation and resaturation in order to make the test challenging and not give time for the monitors to reacquire on non-motion signal. During room air, the motion was persistent for 2 minutes. The motions were both random/erratic using a pseudo random motion generator and periodic at 3 Hz (180BPM). Test and control SpO_2 values were compared in terms of sensitivity and specificity. Sensitivity measured a pulse oximeter's ability to detect 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 (SpO_2 PI and PR PI) and 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 PR PI = %-time that a pulse rate was displayed within 10% of the control. The drop out % measured the total time the SpO_2 displayed was either zero or dashes.

Authors' Discussion and Conclusion

“We used a proven challenging motion and low perfusion protocol which has produced consistent results in several studies to test all commercially available products claiming to work under motion conditions. In our experiments, the Masimo SET pulse oximeter performs significantly better during motion and low perfusion than the other devices. The Masimo SET not only had virtually no drop outs, but also was the only product with high sensitivity and specificity under challenging motion and low perfusion conditions. Masimo SET pulse oximetry represents a significant step forward by providing clinicians with more accurate data with which to treat their patients, particularly in clinical settings in which patient motion is likely.”

Pulse Oximeter	Missed Events	False Alarms	SpO_2 Sensitivity	SpO_2 Specificity	SpO_2 PI	PR PI	Dropout %
Masimo SET	8/440	43/660	98	93	94	83	0.2
Philips/HP Viridia 24C Rev B.0	9/40	6/60	78	90	84	75	1.6
Philips/HP CMS Rev B.0	12/40	10/60	70	83	80	71	3.7
Datex-Ohmeda 3740	13/40	12/60	68	80	80	10	0.0
Datex-Ohmeda 3800	15/40	15/60	63	77	79	9	0.7
Datex-Ohmeda AS/3	4/40	33/60	90	45	77	61	0.2
Nellcor N-395	27/80	27/120	66	78	69	50	4.0
Datex-Ohmeda 3900	16/40	29/60	60	52	68	10	1.0
Novametrix MARS	24/40	35/60	40	42	58	31	2.4
Philips CMS	15/40	42/60	63	30	57	17	0.5
Nellcor N-180	26/40	34/60	35	43	56	14	2.6
Marquette 8000	24/40	33/60	40	45	55	26	0.0
Nellcor NPB-295	49/80	57/120	39	53	55	14	7.8
Novametrix 520A	26/40	42/60	35	30	54	11	0.7
Nellcor N-200	38/80	69/120	53	43	52	18	0.8
BCI 3304	29/40	45/60	28	25	52	10	1.1
Nonin8600	22/40	49/60	45	18	48	11	1.4
SpaceLabs 90308	24/40	46/60	40	23	46	38	0.8
Nellcor NPB 190	21/40	40/60	48	33	44	15	11.1
CSI 5040	28/40	51/60	30	15	28	4	5.4

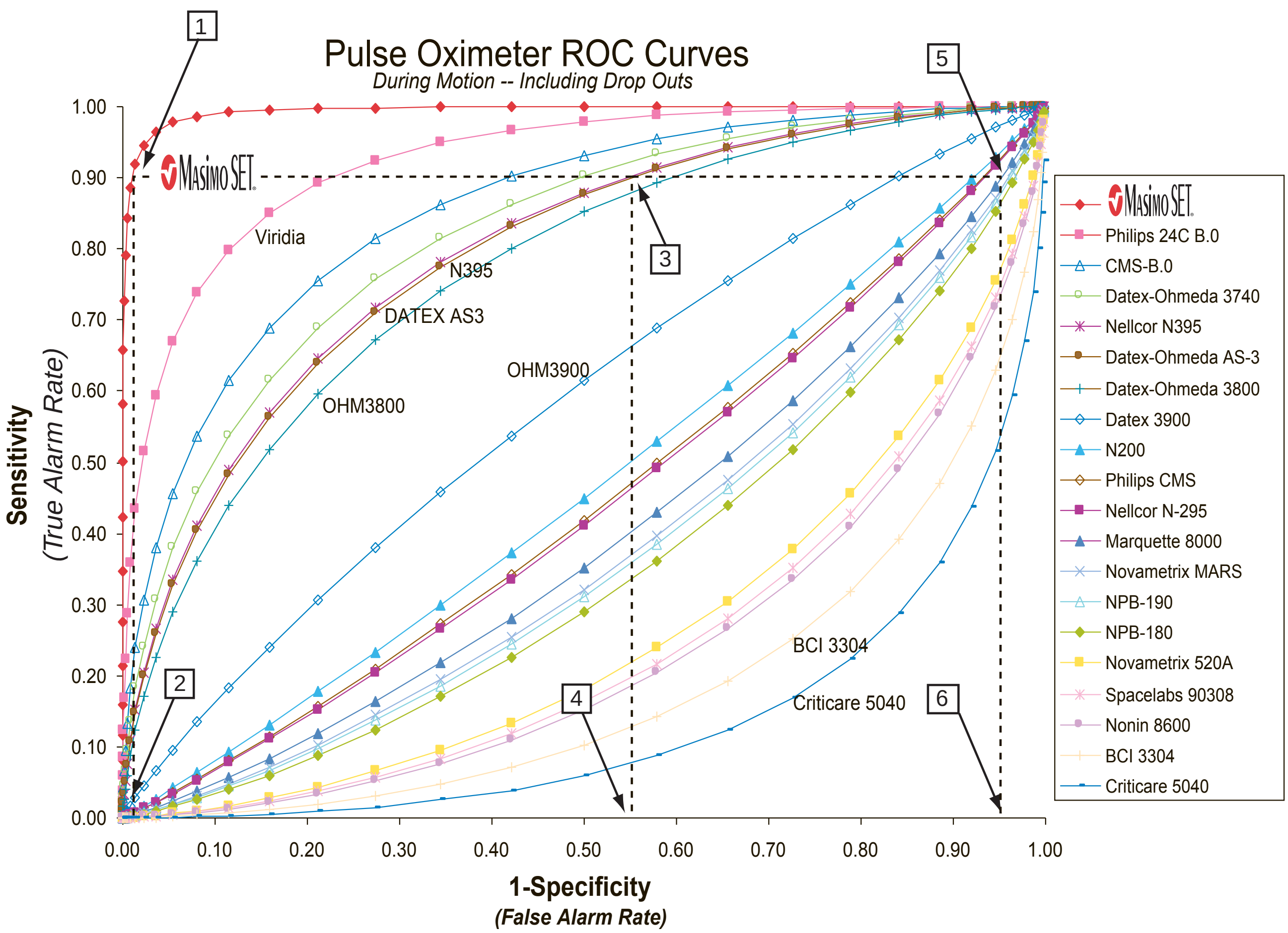

Figure 1: ROC-curves (Receiver Operating Characteristic): The ROC curve is a graph of sensitivity (true alarm rate) versus 1-specificity (false alarm rate). The total area under the ROC curve is a measure of the overall quality of the instrument.

1. For Masimo SET to detect 90% of the true alarms…
2. …you would expect about a 2% false alarm rate.
3. For Nellcor N-395 to detect 90% of the true alarms…
4. …you would expect about a 55% false alarm rate.
5. For Novametrix Mars to detect 90% of the true alarms…
6. …you would expect about a 95% false alarm rate.