Motion Induced Failure of Pulse Oximeters (POs) - Failure Rates and Recovery Times in Human Volunteers.

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Introduction
Patient movement is common in the PACU and in the OR especially at the critical time of extubation. Conventional POs may not function well during motion. How long the PO takes to recover and display accurate SpO2 and PR after motion induced failure may be of paramount importance. Our study compares the recovery time for SpO2 and PR for three major brands with new PO technologies.

Methods
9 ASA-I adult volunteers (4 F & 5 M) between 18 & 40 years of age were enrolled after obtaining informed consent. Masimo Radical (ver 4.3) was compared to Philips CMS (ver C1), and Nonin 9700 (2004). The left hand was the test hand while the right hand served as the control. The sensors were placed randomly on the index, middle and ring fingers. Each of the sensors was covered with a light-shielding bag to prevent optical cross-talk between the sensors. A Masimo PO with ear sensor connected to right ear was used as the control for titration of hypoxemia. Monitoring included ECG and NIBP. The room was cooled to 16-18 degree C to reduce the peripheral perfusion. Hypoxemia was induced employing a disposable re-breathing circuit with a CO_2 absorber to SpO2 of 75% the subjects were then given 100% O2 to breathe until the SpO2 reached 100%. During normoxemia, the motion was performed by a motor-driven motion table (motion generator, MG) as well as by the subject himself (self-generated SG). MG consisted of tapping at 3Hz with disconnect and reconnect of the sensors during motion, random tapping and random rubbing. SG included random tapping with disconnect and reconnect and random rubbing. All POs were tested on index, middle and ring fingers. During hypoxemia, MG consisted of tapping at 3Hz, tapping at 3Hz with disconnect and reconnect of the sensors during motion, random tapping with disconnect & reconnect, and random rubbing. SG included a random tapping with disconnect-reconnect and random rubbing. A computer for off-line analysis recorded SpO2 & PR data. Recovery time (RT), defined as the time required for the POs to recover for SpO2 and PR to the control value, and failure rates (FR), defined as the % of the time the POs displayed values off by 7% for SpO2 and 10% for PR of control value at the end of the motion were also calculated. Analysis of Variance (ANOVA) & Chi-square test were used for statistical analysis & $p < 0.05$ was considered statistically significant.

Results
There were a total of 189 motion tests (117 during MG and 72 during SG) when POs could fail. The table shows our results.

RT and FR of POs during motion via MG and SG

Device		SpO2			Pulse Rate		
Pulse Oximeter		Mean RT in seconds (range)	No. of times fail/total	Failure Rate	Mean RT in seconds (range)	No. of times fail/total	Failure Rate
Masimo Radical (v 4.3)	MG	22.5 (9-36)	2/117	1.7%	13.8 (9-36)	5/117	4.3%
Masimo Radical (v 4.3)	SG	0	0/72	0	10.5 (9-12)	2/72	2.7%
Philips CMS (vC1)	MG	33 (18-60)*	5/117	4.3%*	35.4 (18-84)	10/117*	8.5%*
Philips CMS (vC1)	SG	28.5 (18-30)*	5/72	6.9%	27 (9-42)	11/72*	15.3%*
Nonin 9700 (2004)	MG	17.1 (12-27)	17/117	14.5%*	18 (12-27)	13/117	11.1%*
Nonin 9700 (2004)	SG	18.8 (12-30)	12/72	16.4%*	15.9 (12-24)	7/72	9.7%*

* p=<0.05 versus Masimo Radical

Conclusion Amongst the POs studied it appears that Masimo Radical (ver 4.3) may serve better for monitoring as it has the shortest RT and lowest FR for both SpO2 as well as PR.