Accuracy in patients of pulse oximetry (SpO_2) with different oximeters - Oxygap study

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Abstract

Background

An accurate S_{pO2} value is critical in order to optimally titrate oxygen delivered to patients and to follow oxygenation guidelines. Oximeters' accuracy has not been evaluated with recent oximeters in patients.

The objective of this study was to assess accuracy and bias of the S_{pO2} values measured by several oximeters in hospitalized patients.

Methods

We included stable adults in the intensive care unit with an arterial catheter in place. Main exclusion criteria were poor SpO_2 signal, and $SpO_2 > 96\%$. In each patient, we evaluated at the same time four oximeters: Nonin (Plymouth, MN) embedded in the $FreeO_2$ device (Oxynov, QC, Canada), Masimo (Radical 7, Irvine, CA), Philips (FAST, Eindhoven, Netherlands), and Nellcor (N600, Pleasanton, CA). Arterial blood gases were drawn and simultaneously, SpO_2 values for all oximeters were collected. SpO_2 values were compared to the reference (SaO_2 value) to determine bias and accuracy. The ability for oximeters to detect hypoxemia ($SaO_2 < 90\%$) and the impact of oximeters on oxygen titration were evaluated.

Findings

We included 193 patients (153 men, mean age 66·3 years) in whom 211 sets of measurements were performed. The skin pigmentation evaluated by Fitzpatrick scale showed 96.2% of patients were light skin (types 1 and 2). All SaO_2/SpO_2 correlation coefficients were low (R^2 between 0.43 to 0.51). One oximeter overestimated SaO_2 (Philips, +0·9%) while the three others underestimated SaO_2 (Nonin -3·1%, Nellcor -0·3%,

Masimo -0·2%). SaO_2 was underestimated with Nonin oximeter in 91·3% of the cases while it was overestimated in 55·2% of the cases with Philips oximeter. Hypoxemia was detected in 92%, 33%, 42% and 17% of the cases with Nonin, Nellcor, Masimo and Philips respectively.

Interpretation

We found significant bias and poor accuracy between the tested oximeters and the arterial blood gases, in the studied population. These discrepancies may have important clinical impact on the detection of hypoxemia and management of oxygen therapy.

Figure 1: representation of the Bland & Altman plot for the comparison of the pulse oximeter saturation displayed by tested oximeters with the reference value (arterial oxygen saturation). The Panel A, B, C and D represent the Bland & Altman plot for Nonin, Nellcor, Masimo and Philips oximeters respectively). The blue dotted lines represent the bias, and the red dotted lines represent 95% CI.

Abbreviations:
SpO_2 = pulse oximeter oxygen saturation (as measured by pulse oximeters)
SaO_2 = arterial oxygen saturation (as measured by blood gases)

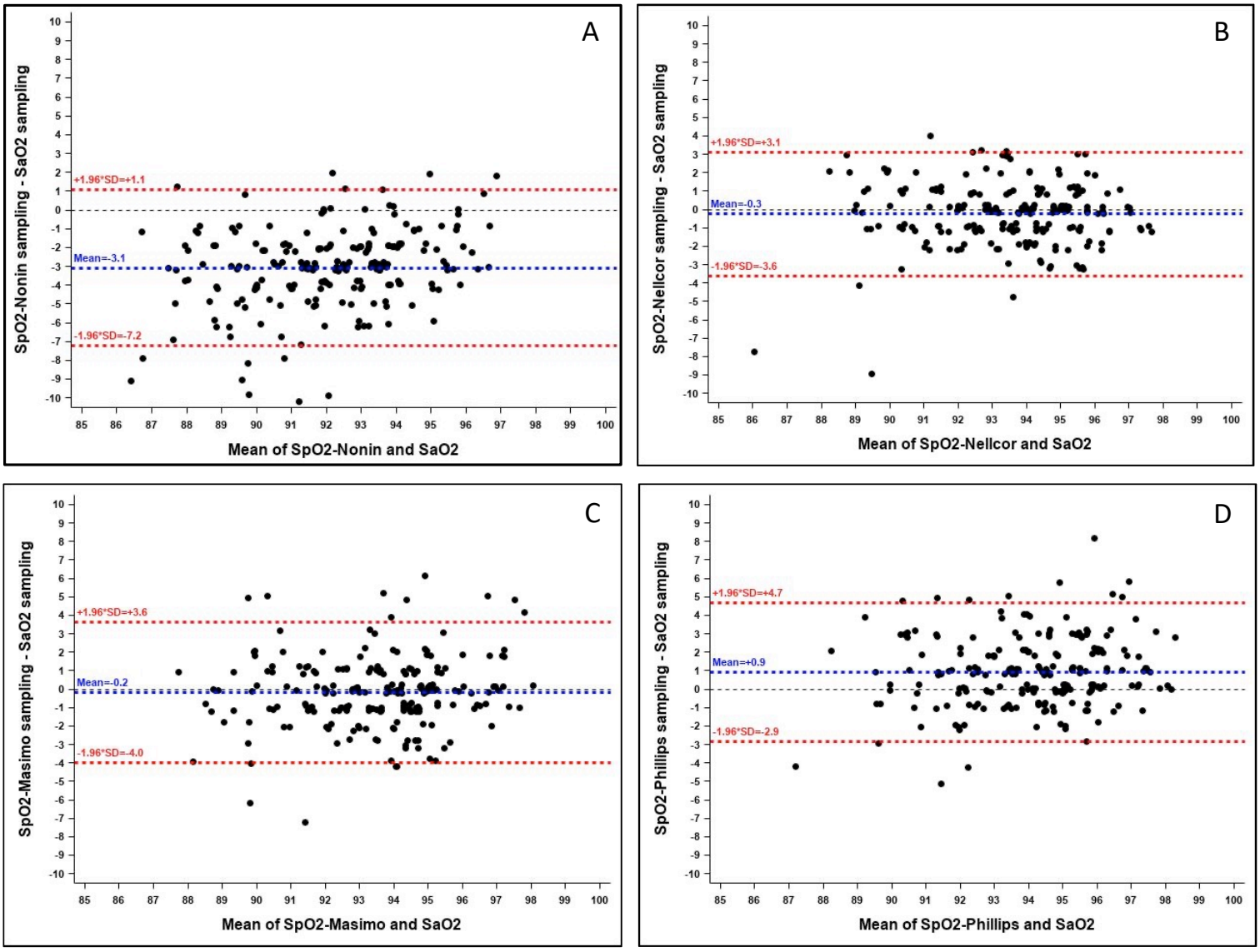

Table 1: Main features of evaluated oximeters. Mean, standard deviation, confidence interval of the bias, percentage of over and underestimation of the SaO_2, large bias (above 4 or 10%) and detection of hypoxemia for tested oximeters.

	SaO_2 (reference)	SpO_2			
		Nonin	Nellcor	Masimo	Philips
O_2 saturation (%) Mean±SD	93.6±2.2	90.5±2.8	93.3±2.3	93.4±2.4	94.5±2.4
Bias (SaO_2-SpO_2) (%) Mean±SD	..	-3.1±2.1*	-0.3±1.7**	-0.2±1.9	0.9±1.9*
Bias confidence intervals (95%)	..	(-3.4; -2.8)	(-0.5; 0.0)	(-0.5; 0.1)	(0.7; 1.2)
Overestimation of SaO_2 (% measurements)	..	3.9	28.2	30.8	55.2
Underestimation of SaO_2 (% measurements)	..	91.3	41.1	42.8	21.4
Bias < -4 or or ≥ +4%, n (%)	..	73 (35)	5 (2)	18 (9)	20 (10)
Bias < -10 or ≥ +10%, n (%)	..	3 (1.5)	0	0	0
Detection of hypoxemia n (%)					
SaO_2 < 90%†	..	11 (92)	4 (33)	5 (42)	2 (17)
PaO_2 < 60 mmHg†	..	19 (100)	5 (26)	7 (37)	2 (11)

* P<0.0001 ** P<0.05

† Based on 12 patients for SaO_2 < 90% and 19 patients for PaO_2 > 60 mmHg

Overestimation was defined by a SpO_2 value > SaO_2 value

Underestimation was defined by a SpO_2 value < SaO_2 value