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Influence of digital clubbing on oxygen saturation measurements by pulse-oximetry in cystic fibrosis patients

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Abstract

Objective: To determine the influence of digital clubbing on oxygen saturation by pulse oximetry measurements (SpO_2) in Cystic Fibrosis patients.
Background: Measuring the arterial oxygen saturation at the fingertip by pulse-oximetry is commonly used in the management of CF patients. In these patients, clinical signs of hyperoxia are often observed with oxygen supplies based on digital oximetry readings. This suggests inaccuracies in the digital measurement method, which in its turn may be caused by digital clubbing. In order to study the influence of digital clubbing, measurements between fingertip and forehead sensor were compared in a clubbing and non-clubbing CF-population. The ear sensor measurements are used as a reference variable.
Methods: Two groups were examined. Group 1 consisted of 50 CF patients without digital clubbing (DPD/IPD ratio < 1.00). Group 2 consisted of 50 CF patients with digital clubbing (DPD/IPD ratio > 1.00). Patients were measured at rest before any treatment and with their daily oxygen supply, if applicable. Saturation was simultaneously measured with three Criticare SpO_2 T pulse oximeters, using a fingertip sensor at the right index (transmission oximetry), a forehead sensor at the forehead (reflectance oximetry) and an ear sensor at the right ear.
Results: Using the Bland and Altman method no clear difference was found between the saturation measurements of right ear versus forehead sensor in the two groups. When the measurements of right ear versus fingertip sensor are compared there is still no difference for the non-clubbing group. On the contrary, for the clubbing group lower saturation scores were measured by the fingertip probe compared to the right ear measurement. The differences in saturation became greater as the saturation value at fingertip was lower.
Conclusion: Digital clubbing significantly influences the registrations of the SpO_2 measurements by means of a fingertip probe, underestimating the saturation. It can be advised to use the ear sensor as good alternative for these patients.

Keywords: Digital clubbing; Arterial oxygen saturation; Pulse-oximetry (SpO_2); Cystic fibrosis

1. Introduction

Measuring the arterial oxygen saturation (SaO_2) by pulse-oximetry (SpO_2), using a fingertip sensor is commonly used in the management of CF patients. Transmission pulse-oximetry is a non-invasive, accurate and simple means of monitoring oxygenation, but this technique has some drawbacks:

It can fail in accuracy when low arterial oxygen perfusion occurs [1–4]. It is sensitive to mechanical artefacts caused by movement of the sensor [5–9]. However, new pulse oximeter designs, using the signal extraction technology (SET), have been demonstrated to improve performance during low perfusion states and patient motion [10–12]. Oxygen saturation results determined by pulse-oximeters of different brands are often not identical [13].

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Table1
Results for SpO_2 in CF patients for the group without (1) and with digital clubbing (2)

Variable	Number of patients	Mean SpO_2 in %	SD	Kolmogorov–Smirnov Z
Forehead (1)	50	96.60	1.58	1.19
Right index (1)	50	96.50	1.54	1.18
Ear (1)	50	96.56	1.58	1.12
Forehead (2)	50	96.72	1.50	1.02
Right index (2)	50	93.18	2.43	0.89
Ear (2)	50	96.66	1.45	1.10

$p < 0.01$. Test division is normal.

Reflectance pulse oximetry is also used for estimating arterial oxygen saturation. Forehead pulse oximetry and monitoring the fetus during labour are examples of this. But literature generally shows that this technique is much more susceptible to all kinds of physiological variations than the well-established transmission pulse oximetry [14–16].

Studies, in which the location of the sensor in relation to determine SpO_2 measurements is questioned, are scarce [14,17,18]. Moreover, artefacts induced by digital clubbing have never been described.

Digital clubbing is a bulbous enlargement of connective tissue within the dorsal surface of the terminal phalanges of the fingers and toes. The association of digital clubbing with diseases of the chest and abdomen is recognized [19]. Nevertheless, the pathophysiological mechanisms leading to digital clubbing remain obscure and there is no unifying hypothesis that explains the occurrence of digital clubbing in CF, whereas the correlation between digital clubbing and pulmonary function alterations (hypoxemia, decreased FEV_1, hyperinflation and non-uniform distribution of ventilation) has been described [20,21].

The aim of this study is to investigate the influence of digital clubbing on oxygen measurements. The measurements are obtained, using a fingertip sensor at the right index (example of the transmission pulse oximetry) and a multi-site sensor at the forehead (example of the reflectance pulse oximetry). Finally an ear sensor at the right ear (transmission pulse oximetry) is applied for having a reference variable in comparison with the other two measurements.

2. Subjects, materials and methods

One hundred CF patients were studied at the Cystic Fibrosis Centre. Oral informed consent was obtained of all patients included in this study.

The patients were examined and divided into two groups. The distal phalangeal depth (DPD) of the finger at the nail base and the interphalangeal depth (IPD) were measured using a Harpenden skin fold calliper (British Indicators, Manchester, England). In order to assess the degree of clubbing, the DPD/IPD ratio was calculated. This ratio was previously found to be a reliable index for the assessment of digital clubbing. A DPD/IPD ratio > 1.00 is defined as digital clubbing, while a DPD/IPD ratio < 1 is defined as normal [20–24].

Group 1 consisted of 50 CF patients without digital clubbing, group 2 consisted of 50 CF patients with marked digital clubbing.

Oxygen saturation was simultaneously measured with three Criticare Systems Inc 503 SpO_2 T pulse oximeters with a standard error ±1% (by Criticare Systems Inc International, 6380 Bad Homburg, Germany). Measurements were obtained at rest before any treatment and with patient's daily oxygen supply, if necessary. Measurements were done, using a 511SD fingertip sensor at the right index, a 516 multi-site sensor at the forehead and one at the right ear simultaneously. All measurements were compared with the Bland and Altman method [22] using the right ear sensor as a reference variable.

The study was approved by the ethics Committee (O.G. 016) of our university hospital (AZ-VUB) with the identification number (2004/172IC).

2.1. Data analyses

The one-sample Kolmogorov–Smirnov Test was used to check normal division of the measurements, while the Bland and Altman method was applied to compare the different measuring methods for the oxygen saturation.

3. Results

Median age of group 1 was 14.6 years (range: 7–22 years), mean baseline was for VC = 96.9%, FEV_1 = 90.1%, MEF_{25} = 73.7% of the predicted values. Mean DPD/IPD ratio = 0.88 (range: 0.83–0.93). Median age of group 2 was 19.1 years (range: 10–33 years), mean baseline was for VC = 68.6%, FEV_1 = 49.2%, MEF_{25} = 20.6% of the predicted values. Mean DPD/IPD ratio = 1.08 (range: 1.06–1.15).

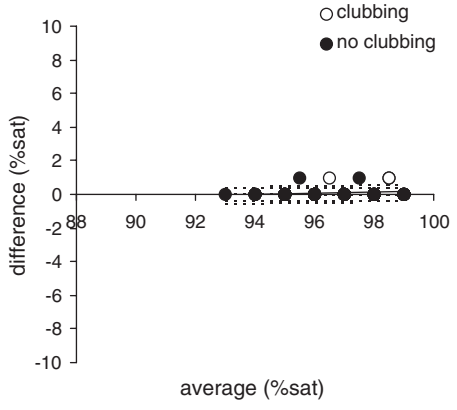

Fig. 1. Bland and Altman method: comparison between ear sensor and forehead sensor.