Advantages of transcutaneous PCO_2 monitoring over $PaCO_2$ in chronic respiratory failure (CRF)

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Background

The study was aimed at assessing the accuracy of transcutaneous PCO_2 ($PtcCO_2$) monitoring compared to $PaCO_2$ and its technical drift during eight hours of nocturnal NIV in patients with stable chronic respiratory failure.

Methods

Only patients with a difference not greater than 2.5 mmHg between $PaCO_2$ drawn from the radial artery compared to $PaCO_2$ from the arterialized earlobe were included in the study.
Accordingly, in 24 patients (15 with COPD) receiving nocturnal NIV capillary blood gases from the arterialized earlobe were analyzed at 11pm, 2am, 5am and 7am. Simultaneously, $PtcCO_2$ was monitored with the newest generation of three different devices: 1) SenTec Digital Monitor (SenTec DM), 2) TCM4-TINA, and 3) TOSCA500. A sensor temperature of 42°C was used for all devices, alarms were switched off.
Technical drift of the devices were analyzed after eight hours. In addition, method comparison to the gold standard $PaCO_2$ were performed, and analysis of patients' individual overnight CO_2-range were investigated in regard to intermittent measurements and continuous monitoring.

Table 1. Technical drift and continuous overnight $PtcCO_2$-monitoring. Median (interquartile range) is given for all patients (N=24).

	SenTec DM	TCM4-Tina	TOSCA500	p-value (RM-ANOVA)
Technical Drift (mmHg)	0.7 (-0.9/3.7)	-4.0 (-8.0/8.0)	-4.0 (-8.0/2.0)	<0.001*
Mean of overnight $PtcCO_2$ (mmHg)	48.5 (36.5/65.9)	47.9 (31.5/68.6)	47.8 (37.6/65.9)	0.718
Standard deviation of overnight $PtcCO_2$ (mmHg)	2.5 (1.1/11.5)	3.2 (0.3/23.0)	2.4 (1.5/12.1)	0.121

$PtcCO_2$ = transcutaneous partial pressure of carbon dioxide.

*lowest technical drift by SenTec DM compared to TCM4-Tina und TOSCA500.

Table 2. Method comparison of $PtcCO_2$/$PaCO_2$-pairs at 11 pm, 2 am, 5 am and 7 am. Results are given for all patients (N=24).

	SenTec DM	TCM4-Tina	TOSCA500
$PaCO_2$ versus drift-uncorrected $PtcCO_2$			
Pairs of values (N)	93	88	92
Mean of the difference (mmHg)	1.0	-1.5	0.8
Limits of agreement (range) (mmHg)	-4.7 to 6.7 (11.4)	-15.6 to 12.5 (28.1)	-6.8 to 8.3 (15.1)
$PaCO_2$ versus drift-corrected $PtcCO_2$	software based	calculated	calculated
Pairs of values (N)	90	80	92
Mean of the difference (mmHg)	0.8	-3.3	-1.6
Limits of agreement (range) (mmHg)	-4.9 to 6.5 (11.4)	-15.8 to 9.3 (25.1)	-8.4 to 5.2 (13.6)

$PaCO_2$ = arterial partial pressure of carbon dioxide, $PtcCO_2$ = transcutaneous partial pressure of carbon dioxide.

Figure 3. Overnight trend of $PaCO_2$ (red boxes) and $PtcCO_2$ (solid line represents SenTec DM, interrupted line represents TCM4-TINA, and dotted line represents TOSCA500) in a 34-year old patient with congenital central hypoventilation syndrome. Between 6.30am and 7am sensors of SenTec DM and TOSCA500 were disconnected from the patient.

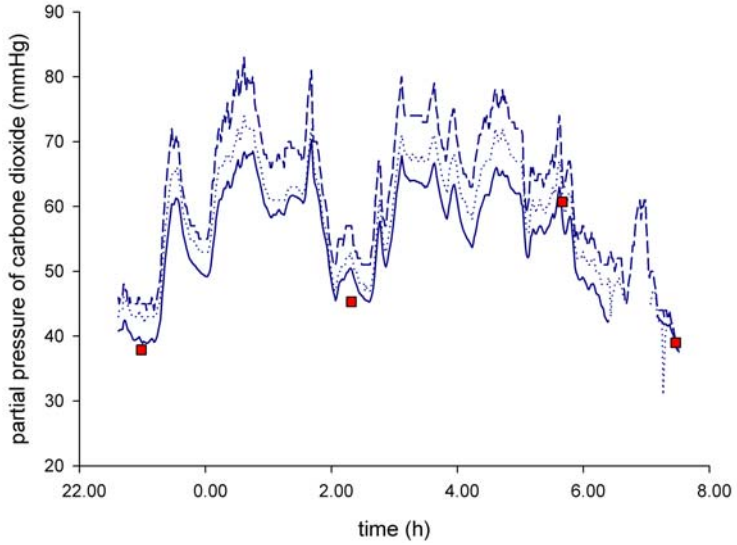


Figure 1: Range of overnight carbon dioxide measurements reflecting intermittent time spots at 11pm, 2am, 5am and 7am (RM-ANOVA, p=0.003).

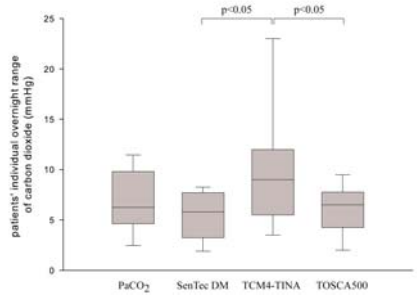
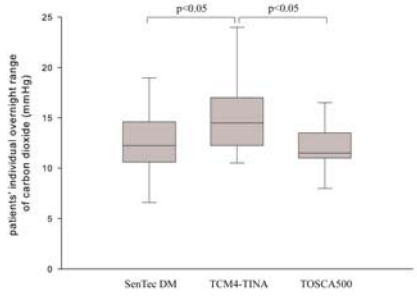


Figure 2: Range of overnight carbon dioxide measurements reflecting continuous transcutaneous monitoring (RM-ANOVA, p<0.001).



Results

The overall technical drift after 8 hours was appropriate for all devices regarding the lowest technical drift produced by SenTec DM, Table 1.
Method comparison by Bland-Altman of $PaCO_2$/$PtcCO_2$-pairs for drift-uncorrected and drift-corrected values are given in Table 2, respectively.
Individual overnight carbon dioxide ranges are illustrated for intermittent measurement points in Figure 1, and for continuous $PtcCO_2$-monitoring in Figure 2.
An overnight trend of $PaCO_2$ and $PtcCO_2$ in a 34-year old patient with congenital central hypoventilation syndrome is pictured in Figure 3.

Conclusion

As a result of technical refinements $PtcCO_2$-monitoring has now been shown to accurately reflect $PaCO_2$ in patients with nocturnal NIV. Since $PtcCO_2$-monitoring is also non-invasive, does not disrupt sleep quality and provides a more complete picture of alveolar ventilation than intermittent capillary $PaCO_2$, $PtcCO_2$ monitoring should become the preferred technique for assessing alveolar ventilation during nocturnal NIV.

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