

Title: THE EFFECT OF ARTERIAL CARBON DIOXIDE TENSION ON TRANSCUTANEOUS OXYGEN

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Introduction. Transcutaneous oxygen tension (PtcO₂) is a widely used monitor of oxygenation in the operating room and ICU, particularly for neonates. Clinical studies have shown that if cardiac output remains in the "normal" range (cardiac index > 2.5), PtcO₂ is a nearly constant fraction of PaO₂ (1). The "transcutaneous index" (TCI), defined as PtcO₂/PaO₂, has average values of 1.1 in prematures, 1.0 in infants, 0.8 in young adults, and 0.6 - 0.7 in the elderly (2). This ratio is known to decrease at low cardiac outputs, but has not been reported to depend upon other physiologic variables. In this study we investigate the effect of PaCO₂ upon TCI in animals with normal to high cardiac index. The effect of transcutaneous electrode temperature (Te) on this relationship is also studied.

Methods. The study involved four young pigs of age 3 - 6 weeks, weighing 9 - 14 kg. Each animal was anesthetized with intramuscular ketamine 10 mg/kg and intubated. Anesthesia was maintained with pentobarbital (10 - 15 mg/kg/hr) and pancuronium for paralysis. A 7.5 Fr thermodilution pulmonary artery catheter was inserted via the femoral vein, and a 20 gauge cannula was placed in the femoral artery. Five PtcO₂ electrodes were applied to the chest and maintained at temperatures from 43° to 45°. Data were recorded during steady conditions at four FIO₂ values: 1.0, 0.5, 0.3, and 0.2. At each FIO₂, minute ventilation was varied to achieve six PaCO₂ values from 18 to 55 torr. The initial PaCO₂ was repeated at the end of each experiment. PA pressures were held at or above baseline, and cardiac index was above 2.7 at all times.

Results. Eighty-four data sets were recorded in 13 "runs" in which PaCO₂ was varied while all other parameters were fixed. Figure 1 shows TCI plotted versus PaCO₂ for three electrode temperatures at FIO₂ = 1.0. Each data point in this figure is an average of all data obtained at the same conditions, i.e., the same FIO₂ and PaCO₂. Error bars indicate standard deviations. In every run, TCI fell significantly with decreasing PaCO₂, often reaching values of less than 0.1 for PaCO₂ < 22 torr. The highest TCI of 0.777 was achieved for the highest Te (45°) at the highest PaCO₂ (44 torr) shown. At the lowest PaCO₂ of 20 torr, TCI for Tp = 45° fell to 0.269, or 0.35 times its original value. Meanwhile for Tp = 43° the TCI fell to 0.065, or 0.20 times its original value. Thus the effect of hypocarbia on TCI appears greatest at low electrode temperatures. The TCI versus PaCO₂ relation is nonlinear, particularly at high Te where there is a "plateau" for PaCO₂ > 35 torr. The decreases in TCI in Figure 1 are statistically significant to a level P < .005 by two-tailed T test. Similar results for TCI during hypocarbia were obtained at other FIO₂ values, as shown in Table 1. Hypercarbia (PaCO₂ up to 65 torr) had little effect on TCI as long as concurrent hypoxemia was avoided.

Discussion. Hypocarbia causes a significant de-

crease in transcutaneous oxygen when other variables (cardiac output and PaO₂) are held constant. This effect has not been reported previously. The hypocarbia effect may be lessened by using high Te, but even at 45° extreme hypocarbia will reduce TCI by a factor of three. PtcO₂ is relied upon to indicate trends in PaO₂ in neonates and infants both in the OR and ICU. When these patients are hyperventilated, the PtcO₂ may yield erroneously low values. We have observed this phenomenon in two patients; further study in humans is needed.

References.

1. Tremper KK, Shoemaker WC: Transcutaneous oxygen monitoring of critically ill adults. Crit Care Med 9:706-709, 1981
2. Tremper KK: Review article: Transcutaneous P_O₂ measurement. Can Anaesth Soc J 31(6):664-677, 1984

Figure 1. Mean TCI versus PaCO₂ at three Te values.

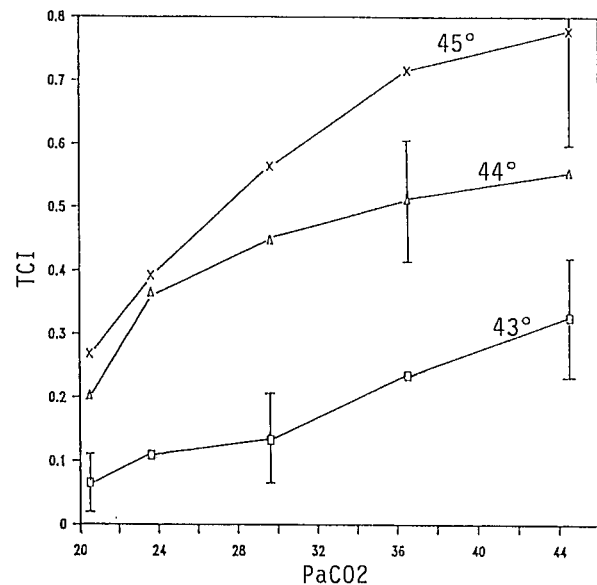


Table 1. Mean TCI values versus FIO₂ and temperature Te. High = TCI at highest PaCO₂; Low = TCI at lowest PaCO₂; Ratio = Low/High

		43°	44°	45°
FIO ₂ = 1.0	High	.326	.555	.777
	Low	.065	.203	.269
	Ratio (Low/High)	.20	.37	.35
0.5	High	.416	.494	.838
	Low	.141	.221	.175
	Ratio	.34	.45	.21
0.3	High	.420	.584	.821
	Low	.097	.248	.441
	Ratio	.23	.42	.54