

# Evaluation of EMMA™ End-Tidal Capnograph and Transcutaneous pCO<sub>2</sub> Under Increased Barometric Pressure

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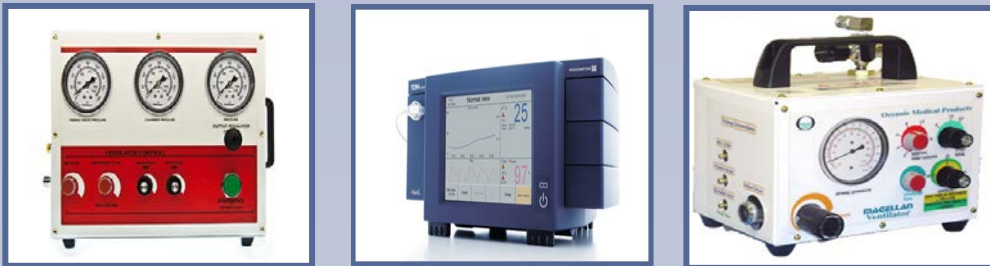
## Background

Most medical equipment is not tested or manufactured for use in the hyperbaric chamber.

- Sparse FDA-approval

The hyperbaric community must test/modify equipment themselves.

Monitoring ventilation in intubated patients during HBOT ensures effective therapy.



### Methods of Ventilatory Assessment

Mechanism	Method of Acquisition	Msmt	Ventilatory Assessment	Accuracy
Arterial Blood Gas	Invasive	PaCO <sub>2</sub>	Direct	±1 mmHg
Gas Perfusion	Non-Invasive	TcPCO <sub>2</sub>	Trend	±1 mmHg
Expiratory Volume	Non-Invasive	EtCO <sub>2</sub>	Trend	±2 mmHg

The Masimo® EMMA™ Emergency Capnograph is a small transportable device that measures EtCO<sub>2</sub>.

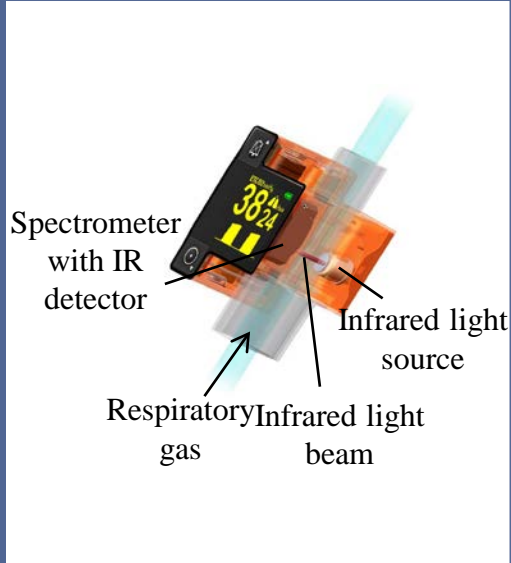
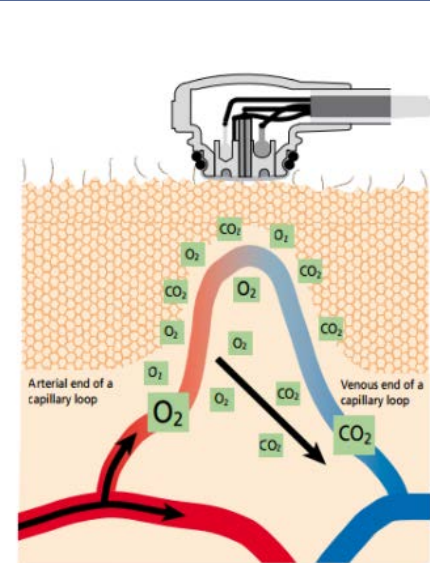
### TcPCO<sub>2</sub> vs. EtCO<sub>2</sub>

**TcPCO<sub>2</sub>**

- Electrolyte Buffer
- Heat Dilation
- Capillary Perfusion
- pH change
- TcPCO<sub>2</sub> value

**EtCO<sub>2</sub>**

- Infrared (IR) Light
- End Expiration
- IR detection
  - λ<sub>CO<sub>2</sub></sub>=425 nm
- EtCO<sub>2</sub> value



## Purpose

To compare simultaneously acquired EtCO<sub>2</sub> (measured by EMMA™) and TcPCO<sub>2</sub> measurements collected under increased environmental pressures.

## Methods

### Materials

#### EtCO<sub>2</sub> Measurements

An Ambu® UltraSeal™ II face mask fitted with a t-piece attached to one-way intake and exhaust valves. EMMA™ (±0.3kPa/±2mmHg) was attached to the face mask system at the distal end of the one-way exhaust valve (total dead space = 280 mL).

#### TcPCO<sub>2</sub> Measurements

A Radiometer America® TCM TOSCA monitor (±1mmHg) was set to 43°C and a tc Sensor 92 was placed over the left second intercostal space of one healthy 29 y.o. male.

### Procedure

The face mask system was sealed to the subject's face with an elastic harness. EMMA™ was compressed with the patient while tc leads were fed through a penetrator to the TOSCA monitor outside.

The tc sensor warmed up for 10 minutes preceding data collection. Subject lay supine during measurements. EtCO<sub>2</sub> and TcPCO<sub>2</sub> samples were simultaneously recorded every 60 seconds.



Face mask system equipped with EMMA™ used to record EtCO<sub>2</sub>



TcPCO<sub>2</sub> set-up with penetrator allowing tc sensor leads to feed to TOSCA monitor outside

## Variables

- EtCO<sub>2</sub>
- TcPCO<sub>2</sub>
- Environmental Pressure/Depth

## Data Analysis

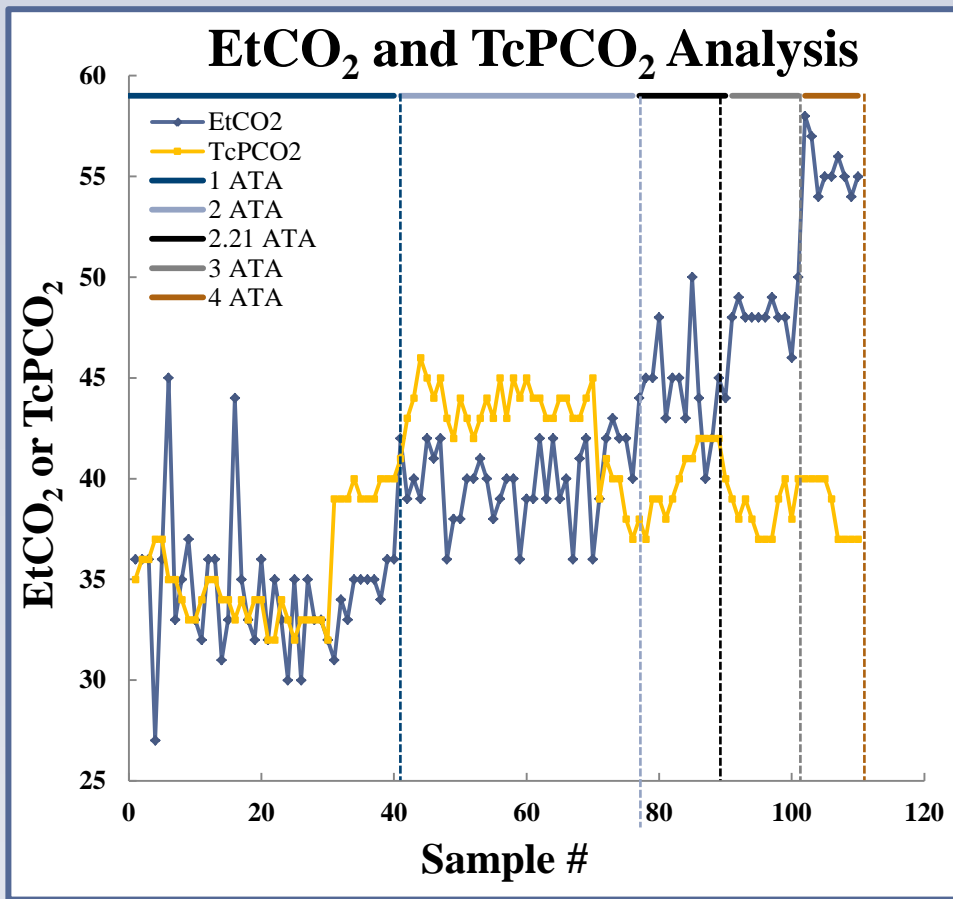
Mean TcPCO<sub>2</sub> and EtCO<sub>2</sub> values acquired simultaneously were compared at varying barometric pressures. Means were tested for differences using a paired samples *t*-test.

IBM SPSS Statistical software package was used to conduct Mann-Whitney *U* statistics to evaluate individual performances of EMMA™ (EtCO<sub>2</sub>) and TOSCA (TcPCO<sub>2</sub>) at varying barometric pressures.

## Results

### EtCO<sub>2</sub> vs. TcPCO<sub>2</sub> Under Increased Pressure

Pressure (ATA)	<i>t</i>	df	<i>p</i>
1	-1.483	39	< 0.001
2	-6.089	35	< 0.001
2.21	5.177	13	< 0.001
3	18.419	10	< 0.001
4	38.48	8	< 0.001



### Independent EMMA™ (EtCO<sub>2</sub>) and TOSCA (TcPCO<sub>2</sub>) Performance Under Increased Pressure

Pressure (ATA)	N	Mean Rank	1 ATA Mean Rank	Mann-Whitney U	Z	<i>p</i>
EMMA™ EtCO <sub>2</sub> vs 1 ATA (N = 40)						
2	42	58.98	23.15	106	-6.851	0.00
2.21	14	46.43	20.88	15	-5.269	0.00
3	22	51.41	20.55	2	-6.503	0.00
4	16	48.5	20.5	0	-5.84	0.00
TOSCA TcPCO <sub>2</sub> vs 1 ATA (N = 40)						
2	36	57.61	21.3	32	-7.192	0.00
2.21	14	43.5	21.9	56	-4.456	0.00
3	11	38	22.7	88	-3.052	0.00
4	9	38.44	21.98	59	-3.157	0.00

## Conclusion

Mean TcPCO<sub>2</sub> and EtCO<sub>2</sub> values varied significantly at 2, 2.21, 3, and 4 ATA. With increasing pressure, mean values exhibited greater differences from sea level values.

The independent performances of both EMMA™ (EtCO<sub>2</sub>) and TOSCA (TcPCO<sub>2</sub>) varied significantly under increased barometric pressure. EMMA™ showed greater variance under increased pressure.

## Discussion

While EtCO<sub>2</sub> displayed variance, further research could confirm a coefficient for EtCO<sub>2</sub> under increasing pressure. This would enable the hyperbaric clinician to utilize this device to assess ventilatory trends despite the limited availability of FDA-approved equipment for HBOT use.

