Ventilator Testing in a Multiplace Hyperbaric Chamber

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Background

The Atlantis BaroVent is an FDA-approved hyperbaric ventilator. Mechanical testing of the ventilator's capabilities under hyperbaric conditions was conducted.

Purpose

Several ventilators are utilized by the hyperbaric community that are not FDA-approved for hyperbaric environments. The volume constant vent poses clinical complications. Oftentimes, many sea level parameters prove inaccurate under increased barometric pressure.

Inaccuracies arise due to environmental changes in pressure. The Atlantis BaroVent's modified timing valve is constantly exposed to sea level pressure allowing the vent to adapt to its environment in order to maintain accuracy. This study aimed to test this specific setting.

Methods

PneuView computer program recorded the tidal volume (Tv), inspiratory time (I), and spontaneous breath rate (SBR) every 30 seconds for 10 minutes.

Three trials were conducted for each trial:
- Ventilator was set per standards
- I = 1.0 second
- SBR = 10 breaths/minute

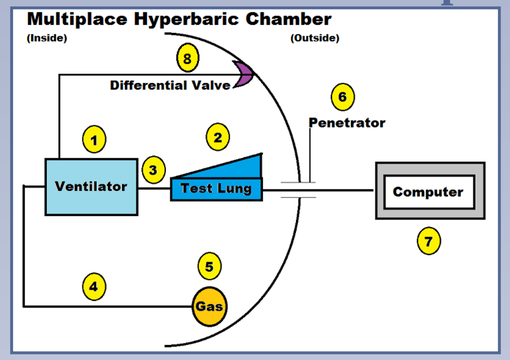
Tidal volume varied per trial to:
- Low: 200-300ml
- Intermediate: 400-500ml
- High: 600-800ml

Measurements were taken at:
- Sea level (1 ATA)
- Stabilized 33 FSW (2 ATA)

Variables

Measurements were taken at 1 ATA and 2 ATA for varying tidal volumes. Tidal volume, I, and SBR were recorded to determine the change in values at varying environmental pressures.

Materials and Set-Up



1) Atlantis BaroVent

2) Michigan Instruments, Inc. 4600 Model single-testing-lung

3) Tubing to connect the ventilator to the test lung.

4) Tubing to connect the ventilator to the gas supply.

5) In-chamber gas supply

6) Penetrator bolt

7) Computer used to run Pneuview test lung computer program.

8) Differential valve connecting allowing ventilator to read outside ambient air pressure.

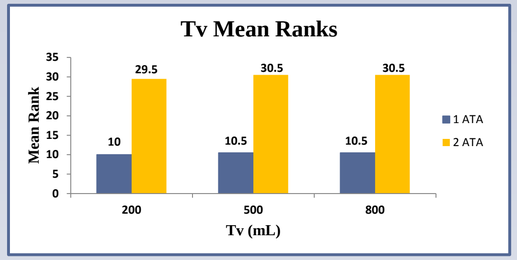
Data Analysis

The data collected was determined to not be normally distributed. A Parametric Levene's determined that there was equal variances among all samples. IBM SPSS Statistical software package was used to conduct Mann-Whitney *U* statistics to evaluate BaroVent performance at varying barometric pressures

Results

	Initial Parameter	Average 1 ATA	Average 2 ATA	%Δ from 1 ATA
		(N=20)	(N=19)	
Tidal Volume(mL)	200-300	235.95	167.211	-29.13%
Inspiratory Time(s)	1	1.1755	1.01526	-13.63%
Breaths/min	10	9.642	11.8363	+22.76%
		(N=20)	(N=19)	
Tidal Volume(mL)	400-500	406.2	265.368	-34.67%
Inspiratory Time(s)	1	1.172	1.01211	-13.64%
Breaths/min	10	9.4875	11.6953	+23.27%
		(N=20)	(N=20)	
Tidal Volume(mL)	600-800	671	405.7	-39.54%
Inspiratory Time(s)	1	1.1505	1.008	-12.39%
Breaths/min	10	9.8875	11.807	+19.41%

Tidal Volume Performance Under Increased Pressure



Pressure	N	Mann-Whitney U	Z	p
Tv Low (200-300 mL/min)				
1 ATA	20	0.000	-5.721	0.000
2 ATA	19			
Tv Inter (500 mL/min)				
1 ATA	20	0.000	-5.634	0.000
2 ATA	20			
Tv High (800 mL/min)				
1 ATA	20	0.000	-5.469	0.000
2 ATA	20			

Comprehensive Tidal Volume Performance Under Increased Pressure

Pressure	N	Mean Rank	Mann-Whitney U	Z	p
Tv All (200-800 mL/min)					
1 ATA	60	74.4	908.000	-4.612	0.000
2 ATA	59	45.4			

Inspiratory Time Performance Under Increased Pressure

Pressure	N	Mean Rank	Mann-Whitney U	Z	p
Tv Low (200-300 mL/min)					
1 ATA	20	29.7	6.000	-5.425	0.000
2 ATA	19	10.3			
Tv Inter (500 mL/min)					
1 ATA	20	29.5	11.000	-5.290	0.000
2 ATA	20	10.6			
Tv High (800 mL/min)					
1 ATA	20	29.6	7.500	-5.417	0.000
2 ATA	20	10.4			

Spontaneous Breath Rate Performance Under Increased Pressure

Pressure	N	Mean Rank	Mann-Whitney U	Z	p
Tv Low (200-300 mL/min)					
1 ATA	20	11.0	0.000	-5.438	0.000
2 ATA	19	31.0			
Tv Inter (500 mL/min)					
1 ATA	20	11.6	13.000	-5.160	0.000
2 ATA	20	30.3			
Tv High (800 mL/min)					
1 ATA	20	11.9	18.000	-5.006	0.000
2 ATA	20	30.1			

Conclusion

The ventilator did not effectively compensate for increasing pressure when diving.

Discussion

Due to the limited marketplace, medical device companies generally do not make devices specifically for use in hyperbaric environments. This results in clinicians needing to modify medical devices or simply not use them.