

# High Altitude Simulation Testing

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# Open Forum Poster

## EVALUATION OF HIGH ALTITUDE SIMULATION GAS DELIVERY METHODS - PROS AND CONS



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**Abstract body: Background:** Gas delivery methods used to perform High Altitude Simulation Testing (HAST), are not well standardized. Additionally, some methods allow assessment of oxygen titration during altitude simulation better than others. Comparing the pros and cons of the various methods may assist in the standardization of this diagnostic procedure. Although performed infrequently, this diagnostic test can be valuable in helping to define if a patient with compromised pulmonary function will require supplemental oxygen when exposed to high altitude conditions. Objective information regarding the most appropriate oxygen flow rate when at altitude can also be helpful.

**Evaluation methods used or suggested include:** Hypobaric or Altitude chamber, vent-mask device using a setting of 35 or 40% O<sub>2</sub>-driven with a 100% Nitrogen gas, mouthpiece/2-way valve assembly, neoprene mask/2-way valve assembly, mouthpiece/demand valve and canopy enclosure.

**Methods:** These six variations are compared and a value assigned based on the pros and cons: 1=poor, 2=fair, 3=good, 4=excellent. Assessments were based on: Patient Comfort, Ease of Communication, Safety, Gas Supply Requirements, Stability of F<sub>IO2</sub> During Testing, Relative Cost, and Ease of Nasal Cannula O<sub>2</sub> Delivery. F<sub>IO2</sub> stability was monitored using a zirconium oxygen analyzer (Medical Graphics Corporation).

**Results:** Scores listed on the table indicate that the hypobaric chamber method yields the lowest score due to cost, patient access, and patient comfort (score=14). Methods utilizing mouthpieces and nose clips also scored lower primarily because of patient comfort. The Venti-mask, neoprene mask with 2-way non-rebreather valve and the canopy method all scored higher due to patient comfort, ease of communication and the ability to deliver nasal cannula oxygen during testing. Scores: Venti-mask=23, Neoprene mask=24, Canopy=25.

**Conclusions:** Patient comfort and the ability to deliver and titrate oxygen during the evaluation are features of the last 3 methods. Air entrainment methods using 100% Nitrogen offer high flow and an inexpensive gas source, however users must ensure there are no obstructions to the entrainment sites which can cause an abrupt reduction in the F<sub>IO2</sub> delivered to the patient. Always analyze and monitor what is being delivered to the patient. Canopy devices used for indirect calorimetry can be adapted to deliver reduced F<sub>IO2</sub>s and offer the most comfortable environment for HAST testing.

**Introduction:** Gas delivery methods used to perform High Altitude Simulation Testing (HAST), are not well standardized. Additionally, some methods allow assessment of oxygen titration during altitude simulation better than others. Comparing the pros and cons of the various methods may assist in the standardization of this diagnostic procedure.

Although performed infrequently, this diagnostic test can be valuable in helping to define if a patient with compromised pulmonary function will require supplemental oxygen when exposed to high altitude conditions. Objective information regarding the most appropriate oxygen flow rate when at altitude can also be helpful. Evaluation methods used or suggested include: Hypobaric or Altitude chamber, vent-mask device using a setting of 35 or 40% O<sub>2</sub> driven with a 100% Nitrogen gas, mouthpiece/2way valve assembly, neoprene mask/2 way valve assembly, Mouthpiece/demand valve and canopy enclosure.

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**Conclusions:** Always analyze and monitor what is being delivered to the patient.

Air entrainment methods using 100% nitrogen offer high flow and an inexpensive gas source, however users must ensure there are no obstructions to the entrainment sites which can cause an abrupt reduction in the F<sub>IO2</sub> delivered to the patient.

Patient comfort and the ability to deliver and titrate oxygen during a HAST are desirable features of the Venti-mask, neoprene mask and canopy enclosure methods.

100% Nitrogen Chamber (canopy for 4)



	Patient Comfort	Ease of Communication	Safety	Gas Supply Requirements	Stability of F <sub>IO2</sub> During Testing	Approximate Cost	Ease of Nasal Cannula O <sub>2</sub> Delivery	Total
Hypobaric Chamber	1 Equalization required	2 Intercom	1 Limited patient access	1 No gas required- however vacuum needed	4	1 >\$500K	4	14
Mouthpiece Demand Valve/2way NRBV/Noseclip	1 Dry mouth, increased resistance, saliva	1 Patient has to write to communicate	2 Increased WOB due to demand valve	4 Low, most gas conserving method	4 Blender or cylinder	2 Demand Valve \$250.00	1	16
Mouthpiece 2 way NRBV/Noseclip	2 Dry mouth, saliva	1 Patient has to write to communicate	4	3	4 Blender or cylinder	3 Inexpensive	1	18
Venti-Mask Device with Nitrogen	2 Plastic mask	3 Loud, high flow	3 Safe as long as diverts are not obstructed	4 Nitrogen is inexpensive	3 Stable, recommend using humidity adapter to protect entrainment opening	4	4	23
Neoprene Mask 2way NRBV	3 Soft mask, no noseclip	3 Obstructs view of mouth	4	3	4 Requires blender or cylinder with flow F <sub>IO2</sub>	3 \$20.00 for neoprene mask or \$1,500 for kit	4	24
Canopy Enclosure	4 Most comfortable	4	4	3	4 Blender, cylinder or air entrainment all can offer stable F <sub>IO2</sub>	2 ~\$2,000	4	25

Approximate F<sub>IO2</sub> Expression

F <sub>IO2</sub> (%)	100	90	80	70
100	100	100	100	100
90	100	100	100	100
80	100	100	100	100
70	100	100	100	100
60	100	100	100	100
50	100	100	100	100
40	100	100	100	100
30	100	100	100	100
20	100	100	100	100
10	100	100	100	100
0	100	100	100	100



Gas delivery assembly used with valve mouthpiece, valve mask, and canopy technique.

# Why talk about HAST?



## High Altitude Simulation Testing

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### [High Altitude Simulation Test \(HAST\), Health Facts For You, UW ...](#)

Proceed to room E5/520. What is a **high altitude simulation test**? Someone with lung disease may need extra oxygen when flying or traveling at high altitudes. ...  
[www.uwhealth.org/.../B\\_EXTRANET\\_HEALTH\\_INFORMATION-FlexMember-Show\\_Public\\_HFFY\\_1126651072799.html](http://www.uwhealth.org/.../B_EXTRANET_HEALTH_INFORMATION-FlexMember-Show_Public_HFFY_1126651072799.html) - Cached - Similar

### [Hypoxia Altitude Simulation Test\\* — CHEST](#)

by CJ Dine - 2008 - Cited by 12 - Related articles

The hypoxia altitude **simulation test** provides a simple way to identify those patients at risk by simulating conditions encountered at **high altitude**. ...  
[chestjournal.chestpubs.org/content/133/4/1002.abstract](http://chestjournal.chestpubs.org/content/133/4/1002.abstract)

# Patient Info / Pre Test Instructions

## High Altitude Simulation Test (HAST)

Test date \_\_\_\_\_

Test time \_\_\_\_\_

This test will be performed in the UWHC Pulmonary Function Lab, Room E5/520. From the main hospital entrance, take the stone path to the D elevators. Go to the 5th floor, turn left, then head left down the first hallway. Proceed to room E5/520.

### What is a high altitude simulation test?

Someone with lung disease may need extra oxygen when flying or traveling at high altitudes. This test has been ordered to see if your oxygen need will increase during these times.

You will be asked to breathe through a mask for about 20 minutes. A clip will be put on your finger to measure your oxygen level throughout the test. If your oxygen level decreases a certain amount, you will have a blood sample drawn from your arm to check the oxygen level in your blood. Oxygen will be added to your mask until we find out how much oxygen is needed to bring your level up to normal. This test will help your doctor know if oxygen will be required and how much will be needed.

### How do I prepare for this test?

- No smoking or breathing in secondhand smoke before the test.
- No heavy exercise before the test.
- Remove finger nail polish.

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# Overview

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- HAST Testing : What is it?
- Literature review: Evidence based?
- Indications for use.
- Safety
- Various delivery methods-*pros and cons*
- Hypoxic gas options
- Practical considerations
- Documentation
- Billing

# Literature Review

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- Aina Akero: I COPD and air travel: Oxygen equipment and preflight titration of supplemental oxygen. Nov 11, **2010**  
CHEST
- Kelly Paul: Predicting the response to air travel in passengers with non-obstructive lung disease: Are current guidelines appropriate? **2009** Asian Pacific Society of Respiriology. (SpO2 correlated, Spiro, TLC and DLCO did not.
- Bradi : Predicting the need for supplemental oxygen during airline flight in patients with chronic pulmonary disease: A comparison of predicted equations and altitude simulation. 2009 Can Respir Journal.
- Mohr, Lawrence C MD, American J Med Sci **2008**
- Martin S.E. et al: Flight assessment in patients with respiratory disease: hypoxic challenge testing vs. predictive equations 2007 Q J Med 2007

# Simulation of Altitude

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- Option 1: Place the patient in an vacuum or hypobaric chamber
- Option 2: Have the patient breath a reduced  $F_{iO_2}$



# Indications for HAST

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- Determine if patients need supplemental O<sub>2</sub> during flight or stays at altitude

- Anemia: Blood Hgb <8.5g/dL
- PaO<sub>2</sub> <70 mm Hg at sea level
- Restrictive and Interstitial lung disease

- Flying

- Staying at altitude



physiologic stress

**got oxygen?**  
Yellowstone National Park • Elevation 8,859'

# Safety Considerations: HAST

- Always monitor delivered FiO<sub>2</sub>
- Continuously observe / monitor your patient ...options:
  - SpO<sub>2</sub>
  - Heart rate
  - Respiratory rate?
  - Signs of cyanosis?
  - If they smoke, SpO<sub>2</sub> may be inaccurate.
  - ECG if cardiac history.
  - Alarms on O<sub>2</sub> analyzer.



# Interpretation\*

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- If PAO<sub>2</sub> during HAST is >55 mmHg
  - No supplemental O<sub>2</sub> required
- If PAO<sub>2</sub> < 50 mmHg
  - O<sub>2</sub> @2LPM
- If PAO<sub>2</sub> is 50-55 mmHg—considered borderline.

\*Hypoxia Altitude Simulation Test Chest / 133 / 4 / April  
2008 J. Dine MD and M. Kreider MD, MS

# Valve Mouthpiece

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- Pros and Cons
    - Simple
    - Hans Rudolph Valve, mouthpiece and noseclips
    - Conserves gas
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- Communication is problematic.
- Stimulates secretions.
  - O<sub>2</sub> titration not possible
  - High level cleaning is required.



# Venti Mask Method

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- Inexpensive
- Can communicate/loud
- FiO<sub>2</sub> fine tuning can be challenging.
- Uses 100% Nitrogen and entrainment of room air.
- Backpressure can cause the FiO<sub>2</sub> to change abruptly.
- O<sub>2</sub> titration is possible



Setting of 35-40%

# Neoprene Mask

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- Pros and Cons
  - Comfortable
  - Communication is possible
  - Titration of nasal O<sub>2</sub> is possible
  - Inexpensive
  - Lower gas use
  - Obstructs view of mouth
  - Some patients do not tolerate



# Canopy Method

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- Well tolerated
- Easy to communicate
- O2 titration is possible
- Easy to clean.
- Patients like it.
- -----
- High flow
- Canopy (Med Graphics or Vacumed)
  - Canopy #17108 \$ 295.00
  - Vail #17109 \$ 95.00



# Other options



Dilution Mask

# Hypoxic Gas Options

- ED cylinders 15%-16% O2  
\$125
- H cylinders of hypoxic mix  
~\$160
- Venti Mask method using  
100% Nitrogen \$6.19
- Blend using Nitrogen  
O2/Nitrogen \$6.19



# A Hypoxic Gas Blender is needed

- Precision Medical®
  - Producer of the HeliO2 Blender
  - Demand of ~ 200 units to justify production.
  - Goal: FiO2 of 12% to 100%
  - 3 gas blender, O2, Nitrogen and Air

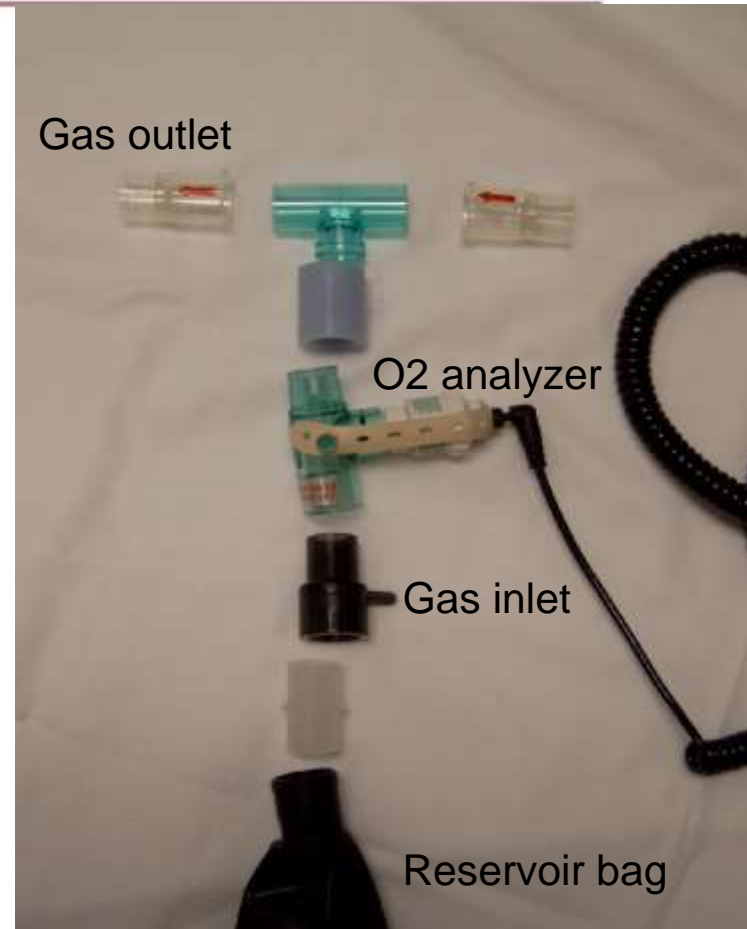


Andy Brown RRT-NPS

Estimated price \$1,600

# Gas Delivery Reservoir

- Enables analysis of  $FiO_2$
- Valves allow for air supply- if flow is not sufficient. (keep bag inflated)
- Also available in kit form from Med Graphics Corp.



# Practical Considerations

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- Always know the FiO<sub>2</sub>
- Different methods ...might.
- Watch for cracks in adaptors
- Make sure one way valves are correctly oriented
- Venti based systems deserve extra caution...very sensitive adjustment.
- SpO<sub>2</sub> do you trust it?
- When do you not draw and ABG?

# Documentation



Pulmonary Diagnostic Lab  
UW Health – UWHC

Age \_\_\_ Gender \_\_\_ Ht \_\_\_" Wt \_\_\_ lbs  
Physician \_\_\_\_\_ Tech \_\_\_\_\_

Diagnosis \_\_\_\_\_

High Altitude Simulation Test (**HAST**)      Date \_\_\_\_\_ Time \_\_\_\_\_

Time	Baseline	min	min	min	min	min	min	min	min
FIO2									
Simulated elevation (feet)									
SpO2 %									
Nasal O2 L/min									
Heart Rate/min									
<b>ABG results</b>									
PO2 mmHg Ref (80-90)									
SaO2 % (95-98)									
PCO2 mmHg (34-46)									
pH (7.36-7.44)									



An FIO2 of 0.15 approximates the PiO2 in an airplane cabin pressurized to 9,000 feet

# Billing

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- CPT Codes:

HAST 94452

HAST with Oxygen: 94453

Add modifier – 26 for professional billing  
(interpretation code)

# Hast Survey Results

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- HAST testing offered? 38% Yes (27 sites)
- FIO<sub>2</sub> used? .14-.16 88%
- # of HAST proc/month? <1 month 63%
- Method used?
  - 28% venturi mask (7)
  - 24% mouthpiece valve (6)
  - 20% neoprene mask (5)
  - 16% NRB mask (4)
  - 12% canopy (3)

# Survey results....

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- ABG performed?
  - 37% always
  - 42% not on non-smokers who maintain a SpO<sub>2</sub> of 90% or greater
- Do you titrate O<sub>2</sub> if SpO<sub>2</sub> drops? 79% yes

# Summary

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- HAST testing is a valuable tool for identifying O<sub>2</sub> needs in ***select*** patients planning long flights or stays at altitude.
- Offering HAST testing adds to the menu of diagnostic tools you can offer.
- HAST testing is relatively easy and reimbursable.

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# Questions

