Nasal Morphology and Blood Flow During Augmented Air Pressure Therapies

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Identify optimum mask humidity & temperature to maintain within normal levels for prescribed mask pressure.

Distal Airways
- \( T = 37^\circ C \)
- \( RH = 100\% \)

Convective Film Coefficient

Nasal Cavity
- Heat
- Fluid

Mucus Layer

Periciliary Fluid Layer

Nasal Epithelia
- MTV (CBF)
- ASL Height (vol)

Vasculature

Purinergic Regulation

Nucleotide Metabolism Model

Stress Induced Stimuli

Pressure Induced Changes

Autonomic Regulation

NO

Nasal Valve Geometry

Air Flow Rate

Mask Pressure

Mask Pressure
Investigate and quantify any change in nasal geometry and blood flows induced by breathing at augmented pressures.
### Participant Distribution

#### Table 1: Distribution of Participant Details

<table>
<thead>
<tr>
<th>Age</th>
<th>Gender</th>
<th>Ethnicity</th>
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</thead>
<tbody>
<tr>
<td>22</td>
<td>Male</td>
<td>Asian</td>
</tr>
<tr>
<td>21</td>
<td>Male</td>
<td>Indian</td>
</tr>
<tr>
<td>53</td>
<td>Female</td>
<td>European</td>
</tr>
<tr>
<td>30</td>
<td>Male</td>
<td>European</td>
</tr>
<tr>
<td>29</td>
<td>Male</td>
<td>Middle Eastern</td>
</tr>
<tr>
<td>35</td>
<td>Female</td>
<td>Asian</td>
</tr>
<tr>
<td>33</td>
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<td>South American</td>
</tr>
<tr>
<td>26</td>
<td>Female</td>
<td>European</td>
</tr>
</tbody>
</table>

#### Table 2: Distribution of Participant Breathing Pressure.

<table>
<thead>
<tr>
<th>Pressure (cm WG)</th>
<th>Male Participant Number</th>
<th>Female Participant Number</th>
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</thead>
<tbody>
<tr>
<td>15</td>
<td>108</td>
<td>115</td>
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<tr>
<td>12</td>
<td>107</td>
<td>109</td>
</tr>
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<td>9</td>
<td>101</td>
<td>106</td>
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<td>6</td>
<td>104</td>
<td>118</td>
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</tbody>
</table>
Measurement of Nasal Cycle Status
<table>
<thead>
<tr>
<th>Participant</th>
<th>Pre-Test MVV (litres/min)</th>
<th>Post-Test MVV (litres/min)</th>
<th>Patent Nasal Passage</th>
<th>Change in Nasal Cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right Nare</td>
<td>Left Nare</td>
<td>Right Nare</td>
<td>Left Nare</td>
</tr>
<tr>
<td>101</td>
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<td>10.3</td>
<td>not detected</td>
<td>12.6</td>
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<tr>
<td>104</td>
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<td>8.9</td>
<td>8.6</td>
<td>6.8</td>
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<tr>
<td>106</td>
<td>11.4</td>
<td>10.5</td>
<td>11.1</td>
<td>Not detected</td>
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<tr>
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<td>8.0</td>
<td>6.3</td>
<td>6.7</td>
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<tr>
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<td>8.1</td>
<td>8.5</td>
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<td>13.5</td>
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</tr>
</tbody>
</table>
Change in Nasal Geometry

Cross-Sectional Area
Cross-Sectional Perimeter
Volume
Surface Area
Overall Nasal Air-conditioning Parameters

Nasal Surface Area

Nasal Volume

Nasal Surface Area to Volume Ratio

\(\triangle\) male, \(\square\) female, \(\diamond\) combined.
Distribution of nasal volume change.

Change in congested airway volume (mm³) against Change in patent airway volume (mm³).

Lines represent:
- Green: 15 cm H₂O
- Red: 12 cm H₂O
- Blue: 9 cm H₂O
- Black: 6 cm H₂O
Nasal Blood Flow - Arterial Spin Labelling
Male Ambient

Male 15 cmWG
Patent

Male Ambient

Male 6 cmWG
Change in perfusion and volume. (A) Airway volume. (B) Patent airway inferior turbinate blood volume.

Using a single sample two t-test, where null equals a mean of zero, pressure significantly changes \( p=0.01759 \) the congested airway volume but does not significantly change \( p=0.452 \) patent airway volume. There was no significance between male/female data.

Aylmer test for count data pressure causes a significant change in blood volume \( p=0.04762 \)

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Change in perfusion and volume. (A) Airway volume. (B) Patent airway inferior turbinate blood volume.

- patent airway
- congested airway

\( \triangle \) male, \( \square \) female.
Conclusions from MRI Investigation

1. Nasal Parameters of:
   - Cross-Sectional Area
   - Cross-Sectional Perimeter
   - Volume
   - Surface Area

   are all within normal physiological limits over the range of augmented air-pressures considered.

2. Nasal blood flow through patent airway erectile tissue changes in response over the range of augmented breathing pressures considered.

3. Morphological nasal examination during augmented air-pressure breathing should consider the influence of patent and congested nasal erectile tissue active compliance characteristics.
Acknowledgements

Assoc. Prof. Brett Cowan and Dr Beau Pontré, both from the Centre for Advanced MRI (CAMRI), University of Auckland.

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Kesavanathan et al. (1995), (Brugel-Ribere et al., 2002).