History of Ventilation

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Declarations of Interest

None

“I can make no claim to originality – beyond, perhaps, the orientation of the material – I can accept sole responsibility for inadequacies, errors or omissions; some shortcomings known to me I hope may eventually be rectified”
Breath as Life

Thou takest away their breath, they die and return to dust

Psalms 104:29
Isis as a kite flapping wings over the corpse of Osiris.
Relief from the temple of Seti I in Abydos.
“and the Lord God formed man of the dust of the ground and breathed into his nostrils the breath of life; and man became a living soul”

Gen 2:7

Synonymous with ‘spirit’ and ‘soul’ in Judaeo-Christian culture; inspiration, respiration.
"the heavenly breath created the earth, the breath of the earth created man, and the breath animated his liver".

Vāyu Hindu deity the lord of the winds or Prāṇa "the breath".

Huang Ti Yellow Emperor (2698 to 2598 BC)
So great is the need for wind for all bodies that while a man can be deprived of every thing else, both food and drink, for two, three or more days, and live, yet if the wind passages into the body be cut off he will die in a brief part of a day, showing that the greatest need for a body is wind.
Pneuma

In ancient Greek medicine, *pneuma* is the form of circulating air necessary for the systemic functioning of vital organs.

- Rushes through the arteries
- Sustains consciousness
- Warm mobile "air" that in the sperm transmits the capacity for locomotion and certain sensations to the offspring.
- A fragment of the pneuma that is the soul of God (Zeus).
The Confusion of Respiration
“the nostrils conveyed air to the heart and lungs (and to the belly)

There were "four vessels for the two ears, two on the right and two on the left. The breath of life enters by the right ear and the breath of death enters the left Ear"

"the Breath from the hollowed hand of the Priest.... is allowed by the Heart to enter his vessels..... It penetrates right down to the Rectum"
For when a man draws breath into himself, the air first reaches the brain and so is dispersed through the rest of the body, though it leaves in the brain its quintessence and all that it has of intelligence and sense.
“The variations in the breaths cause the various diseases. If the breaths are violent (many), they produce disease, as they also do if they are very light (few).

The changes too of breaths give rise to disease ... Towards excessive heat or towards excessive cold.”
Respiration.... existed to cool the innate heat of the heart.

The School of Athens
Internal Heat

Cool air drawn in

Cooling effect

Lungs expand

Lungs contract
• The air introduced by breathing served to cool and to regulate the innate heat of the heart.

• The pumping action of the chest served to introduce into the blood the *pneuma*, which were thence distributed over the body by the arteries.

• The same action served to get rid of the *friligimous*, the products of the innate fire burning in the heart.
Development of ventilatory support

• To enable study of the lungs
• Resuscitation
• Thoracic surgery
• Polio outbreak
Hippocrates
“one should introduce a cannula into the trachea along the jaw bone so that air can be drawn into the lungs”

Galen (129 – 200 AD)
Inflated lungs of dead animals via the trachea and concluded that air movement caused chest “arises”

Paracelsus (1493 – 1541)
Credited with providing the first form of mechanical ventilation. ‘Fire Bellows’ were connected to a tube inserted into the mouth to assist ventilation.

Vesaleus (1514 – 1564)
Describes blowing into a tube to resuscitate a sow via a tracheostomy tube.
“Preserving Animals Alive by Blowing through their Lungs with Bellows”

October 24th 1667
Royal Society, London
Hooke first performed his demonstration of keeping a dog alive without any respiratory movements by passing a constant flow of air into the animal.

“This being continued for a pretty while, the dog . . . lay still, as before, his eyes being all the time very quick, and the heart beating very regularly: But, upon ceasing this blast, then suffering the Lungs to fall and lye still, the Dog would immediately fall into Dying convulsive fits; but be as soon reviv’d again by renewing the fullness of his lungs with the constant blast of fresh air . . .”
'I shall shortly further try, whether the suffering the Blood to circulate through a vessel, so as it may be openly exposed to the fresh Air, will not suffice for the life of an animal.'
Resuscitation – Observations on Death & Dying

- You are unconscious
- You stop breathing
- You cool down
- Your heart stops
When Elisha reached the house, there was the boy lying dead on his couch. He went in, shut the door on the two of them and prayed to the LORD.

Then he got on the bed and lay upon the boy, mouth to mouth, eyes to eyes, hands to hands. As he stretched himself out upon him, the boy's body grew warm. Elisha turned away and walked back and forth in the room and then got on the bed and stretched out upon him once more.

The boy sneezed seven times and opened his eyes.
Early Resuscitation techniques
Positive Pressure Ventilation.

Respiration by means of Bellows
Doubts about PPV

• Barotrauma
• ‘Blind’ Intubation
• Protecting the airway

(1) as the bellows may not be at hand;
(2) as the lungs of one man may bear, without injury, as great a force as those of another can exert, which by the bellows cannot always be determined;
(3) the warmth and moisture of the breath would be more likely to promote the circulation than the chilling air forced out of a pair of bellows.

J. Fothergill, Phil. Trans. R. Soc. Lond., 1745, 43, 275. ‘Observations on a case published in the last volume of the Medical Essays Etc. of recovering a man dead in appearance, by distending the lung with air.’

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Negative Pressure Ventilators

Drinkers' and Shaw's iron lung (1929)
The Fell O'Dwyer apparatus (circa 1888)

Janeway and Green Rhythmic inflation apparatus (1909)

Brauer's positive-pressure apparatus (1905)
Anaesthetic Advances

Laryngoscopy

Endotracheal cuffed tubes

Improved positive ventilators
Bjorn Ibsen (1915 – 2007)
The Epidemic of Poliomyelitis in Copenhagen, 1952

By H. C. A. Lassen

Professor of Epidemiology, University of Copenhagen
Chief Physician Blegdam Hospital, Copenhagen, Denmark

TABLE VI.—MORTALITY RATES

<table>
<thead>
<tr>
<th>Group</th>
<th>Period of admission</th>
<th>No. of cases</th>
<th>No. died</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>7/7 –25/8</td>
<td>31</td>
<td>27</td>
<td>87</td>
</tr>
<tr>
<td>II</td>
<td>26/8 – 8/9</td>
<td>50</td>
<td>27</td>
<td>54</td>
</tr>
<tr>
<td>III</td>
<td>8/9 –23/9</td>
<td>50</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>IV</td>
<td>23/9 – 5/10</td>
<td>50</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>V</td>
<td>6/10–21/10</td>
<td>50</td>
<td>13</td>
<td>26</td>
</tr>
<tr>
<td>VI</td>
<td>21/10– 6/11</td>
<td>50</td>
<td>18</td>
<td>36</td>
</tr>
<tr>
<td>VII</td>
<td>6/11–23/12</td>
<td>50</td>
<td>11</td>
<td>22</td>
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</table>

Total II–VII 300 114 38
Table 1. Blood pH and $PCO_2$ values in a 5-yr-old boy after the onset of manual ventilation

<table>
<thead>
<tr>
<th>Hour</th>
<th>Blood</th>
<th>pH</th>
<th>$PCO_2$, mmHg</th>
<th>$CO_2$ conc, mmol</th>
<th>Bicarbonate, mmol</th>
</tr>
</thead>
<tbody>
<tr>
<td>11:40 AM</td>
<td>venous</td>
<td>6.99</td>
<td>150</td>
<td>39.0</td>
<td>34.5</td>
</tr>
<tr>
<td>2:10 PM</td>
<td>arterial</td>
<td>7.52</td>
<td>32</td>
<td>24.4</td>
<td>24.5</td>
</tr>
<tr>
<td>3:05 PM</td>
<td>arterial</td>
<td>7.65</td>
<td>14</td>
<td>15.6</td>
<td>15.2</td>
</tr>
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</table>

Table 2. Blood pH and $PCO_2$ values in a 30-yr-old woman during manual ventilation over 13 days

<table>
<thead>
<tr>
<th>Date</th>
<th>Hour</th>
<th>Blood</th>
<th>pH</th>
<th>$PCO_2$, mmHg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sept 1</td>
<td>1:00 PM</td>
<td>venous</td>
<td>7.49</td>
<td>32</td>
</tr>
<tr>
<td>2</td>
<td>4:45 PM</td>
<td>&quot;</td>
<td>7.47</td>
<td>31</td>
</tr>
<tr>
<td>2</td>
<td>9:15 AM</td>
<td>&quot;</td>
<td>7.50</td>
<td>32</td>
</tr>
<tr>
<td>2</td>
<td>10:30 AM</td>
<td>arterial</td>
<td>7.50</td>
<td>36</td>
</tr>
<tr>
<td>2</td>
<td>10:35 AM</td>
<td>venous</td>
<td>7.47</td>
<td>34</td>
</tr>
<tr>
<td>2</td>
<td>2:15 PM</td>
<td>&quot;</td>
<td>7.48</td>
<td>36</td>
</tr>
<tr>
<td>4</td>
<td>9:10 AM</td>
<td>&quot;</td>
<td>7.55</td>
<td>30</td>
</tr>
<tr>
<td>6</td>
<td>10:55 AM</td>
<td>arterial</td>
<td>7.55</td>
<td>30</td>
</tr>
<tr>
<td>8</td>
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<td>venous</td>
<td>7.56</td>
<td>31</td>
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<tr>
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<td>&quot;</td>
<td>7.70</td>
<td>17</td>
</tr>
<tr>
<td>13</td>
<td>10:10 AM</td>
<td>&quot;</td>
<td>7.56</td>
<td>23</td>
</tr>
</tbody>
</table>

The physiological challenges of the 1952 Copenhagen poliomyelitis epidemic and a renaissance in clinical respiratory physiology

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Copenhagen Polio Outbreak

- New Positive Pressure ventilators
  - ‘mechanical students’
  - Periodic sigh breaths
  - Weaning Strategies
- Arterial blood gases; the importance of PaCO2 and pH
- Airway protection
- Humidification
- Controlled oxygen
- physiotherapy
Anne Isberg
aged 8
Positive End-Expiratory Pressure
PEEP

THE LANCET

Ashbaugh DG et al

‘Acute respiratory distress in adults.’

Mechanical Ventilatory Support

- Positive End-Expiratory Pressure (PEEP)
- Proportional Assist Ventilation (PAV)
- Airways Pressure Release Ventilation (APRV)
- High Frequency Oscillatory Ventilation (HFOV)
The New England Journal of Medicine

VENTILATION WITH LOWER TIDAL VOLUMES AS COMPARED WITH TRADITIONAL TIDAL VOLUMES FOR ACUTE LUNG INJURY AND THE ACUTE RESPIRATORY DISTRESS SYNDROME

THE ACUTE RESPIRATORY DISTRESS SYNDROME NETWORK*
Thank you