Role of a sustained inflation at birth

Stuart Hooper
Should a liquid-filled lung be ventilated in the same way as an air-filled lung?

Will they behave the same?
**Inspiration**

Inflation Pressures drives airway liquid movement
Pressures generated by Inspiration drives airway liquid movement.
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Partial airway liquid retention
non-uniform ventilation
Should a liquid-filled lung be ventilated in the same way as an air-filled lung?

Will they behave the same?
Ventilation: the basics

Inspiration
Exhalation

When the lung is liquid-filled:
Inspiration - needed for airway liquid clearance
Expiration - superfluous as no gas exchange
Uniform Lung aeration
Sustained Inflations
What are the Unknowns??

- How long should the sustained inflation be?
- What Inflation pressure?
Physics of lung aeration

\[ R_T = R_1 + R_2 \]

\( R_1 \) = resistance to moving liquid through a tube
\( R_2 \) = resistance to moving liquid across alveolar wall

\[ R_1 \propto \text{viscosity} \times \text{length tube} \div (\text{radius tube})^4 \]

\( R_2 \) determine by epithelial barrier properties and surface area

**Smaller very preterm infants:**
Smaller airways + lower surface area = \[\uparrow\uparrow\uparrow\] Resistance
2010 ILCOR Guidelines

Recommend inflation pressures of:

- 30 cmH\(_2\)O in term infants and
- 20 to 25 cm H\(_2\)O in preterm infants
  “occasionally higher pressures are required”.
Duration & Inflation pressure for a SI

\[ R_T = P \times \frac{T}{\Delta V} \]
Effect of age on SI starting pressure

![Graph showing the effect of age on SI starting pressure. The graph has bars indicating the starting pressure (cmH2O) for different gestational ages at delivery (days). The bars show a decrease in pressure as age increases.]
Effect of age SI duration and airway resistance
Sustained Inflations: where are we?

- Inflation Pressure and duration will differ between infants:
  - Airway size
  - Maturity of the distal airways
  - The volume of airway liquid present at birth

- Solution??
  - Target an inflation volume of 20mL/kg
American NRP text book

**Textbook**

**6th Edition**

**Neonatal Resuscitation**

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**Figure 1.8.** Sequence of physiological events in animal models from multiple species involving complete total asphyxia. Note the prompt increase in heart rate as soon as resuscitation is begun.
Cardiopulmonary resuscitation

What do the guidelines say?

- **HR <60bpm** (apneic, non-responsive infants)
  - Start chest compressions
  - IV epinephrine

- **Respiratory support**
  - ILCOR - No consensus
    - “initiation of intermittent positive-pressure ventilation at birth can be accomplished with either shorter or longer inspiratory times”
  - European - 5x 3 sec inflations
Cardiopulmonary resuscitation

“Establishing pulmonary ventilation is the key”

How???

- Conventional 60 breaths/min
- 5x 3 sec inflations
- 30 sec sustained inflation
Protocol

Deliver & Clamp cord

Start resuscitation
BP = 20-25 mmHg

Finish 30 min after Resuscitation start

Groups
1. Conventional 60 breaths/min
2. 5x 3 sec inflations
3. 30 sec sustained inflation

Outcomes
1. Restoration of HR >120 bpm
2. Restoration of BP > 40 mmHg
3. Respiratory mechanics
HR Changes

Resuscitation start

- 5 x 3 s SI
- 1 x 30 sSI
- No SI

Heart rate (BPM)

Time from resuscitation onset (s)
Restoring cardiac function
Why is a SI so effective?

- Better at aerating the lung
  - To increase $O_2$ uptake
  - To increase PBF and increase preload
- But is this a good thing??
  - Could the higher BP cause brain haemorrhage
Blood brain barrier

- Extravasation of serum indicates disruption to the blood brain barrier.

Extravasation
(Immunoreactive blood vessel)

No extravasation
Sheep serum extravasation—blood brain barrier disruption

<table>
<thead>
<tr>
<th>Groups</th>
<th>Number of animals with sheep serum extravasation</th>
</tr>
</thead>
<tbody>
<tr>
<td>No SI</td>
<td>4/6</td>
</tr>
<tr>
<td>Multiple SI</td>
<td>3/6</td>
</tr>
<tr>
<td>Single SI</td>
<td>6/6</td>
</tr>
</tbody>
</table>
Blood brain barrier disruption

There were more animals showing BBB disruption after a 30 sec SI

Data presented as median (IQR)
Summary

- Sustained inflation is fantastic at increasing HR in severely asphyxic newborns
- **But!!** the return in circulation may be too quick and should be tempered to prevent brain haemorrhage