Pulmonary Dead Space Fraction and Extubation Success in Children Undergoing Cardiac Surgery

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Abstract

Objectives: To investigate if pulmonary dead space fraction (VD/VT) can be used successfully in children undergoing cardiac surgery to identify children at risk for prolonged mechanical ventilation and children ready for extubation.

Methods: Retrospective chart review of 461 patients at Phoenix Children’s Hospital in the pediatric cardiac intensive care unit, with 99 patients meeting all inclusion criteria.

Results: Initial post-operative and pre-extubation VD/VT values correlated with length of mechanical ventilation for patients with two ventricle physiology. Pre-extubation VD/VT values of greater than 0.5 indicated higher rates of extubation failure in two ventricle patients.

Conclusion: For two ventricle patients, VD/VT should be used clinically to assess the length of mechanical ventilation and should be checked before attempting to extubate and if higher than 0.5, extubation should not be attempted since the patient is at a much higher risk for extubation failure.

Introduction

- Children with prolonged mechanical ventilation after cardiac surgery have a higher risk for poor outcome due to a variety of ventilator-associated morbidities.
- VD/VT has been suggested to be a possible indicator of prolonged mechanical ventilation.1
- VD/VT measures the amount of ventilated air that is unable to participate in gas exchange.2
- In one study, VD/VT of 0.50 or lower were shown to be reliable predictors of successful extubation, while VD/VT greater than 0.65 successfully identified patients at risk for respiratory failure following extubation.1

Methods

- Retrospective chart review at Phoenix Children’s Hospital in the pediatric cardiac intensive care unit.
- Respiratory variables were recorded throughout the first 72 post-operative hours.
- Inclusion Criteria: Ages 0-18 years, underwent open heart cardiac surgery from October 2013 through December 2014, had Philips NM3 monitors, and intubated post-operatively for greater than 12 hours.
- Exclusion Criteria: Lack of arterial access post-operatively, known pulmonary malformations, tracheostomy, asphyxiating thoracic dystrophy, and prolonged intubation for reasons unrelated to surgery.
- 461 patients screened with 99 meeting all inclusion criteria.

- Out of these 99 patients, 29 with balanced single ventricle physiology and 61 with two ventricle physiology.

Results

Table 1: Characteristics of patients with Single Ventricle Physiology vs Two Ventricle Physiology

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Single Ventricle Physiology (n=29)</th>
<th>Two Ventricle Physiology (n=61)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-Op Intubation Time in hours (IQR)</td>
<td>88.0 (45.7-138.2)</td>
<td>51.8 (19.4-115.5)</td>
<td>0.580</td>
</tr>
<tr>
<td>Initial Post-Op VD/VT (IQR)</td>
<td>0.57 (0.51-0.64)</td>
<td>0.38 (0.31-0.51)</td>
<td>0.017</td>
</tr>
<tr>
<td>Pre-Extubation VD/VT (IQR)</td>
<td>0.54 (0.42-0.60)</td>
<td>0.42 (0.31-0.55)</td>
<td>0.014</td>
</tr>
<tr>
<td>Extubation failure (%)</td>
<td>6 (20.7)</td>
<td>12 (19.7)</td>
<td>0.912</td>
</tr>
<tr>
<td>Extubation failure within 24 hours (%)</td>
<td>5 (83.3)</td>
<td>4 (33.3)</td>
<td>0.046</td>
</tr>
</tbody>
</table>

Table 2: Rate of Extubation Failure in patients with Single Ventricle Physiology vs Two Ventricle Physiology in Relationship to Pre-Extubation VD/VT

<table>
<thead>
<tr>
<th>Extubation Failure in Single Ventricle Patients</th>
<th>Pre-Extubation VD/VT ≤0.5</th>
<th>Pre-Extubation VD/VT &gt;0.5</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exubation Failure in Single Ventricle Patients</td>
<td>18.2%</td>
<td>14.3%</td>
<td>0.7949</td>
</tr>
<tr>
<td>Exubation Failure in Two Ventricle Patients</td>
<td>7.1%</td>
<td>27.8%</td>
<td>0.0316</td>
</tr>
</tbody>
</table>

Discussion and Conclusions

- Initial post-op VD/VT (first value collected upon patient exiting the operating room) and pre-extubation VD/VT (last recorded value within 12 hours prior to extubation) correlated with the length of mechanical ventilation for two ventricle patients but not for single ventricle patients.
- Thus, VD/VT should be used clinically to assess the length of mechanical ventilation for two ventricle patients.
- Single ventricle patients had higher initial post-op VD/VT values, pre-extubation VD/VT values, and rates of extubation failure within the first 24 hours vs two ventricle patients.
- Pre-extubation VD/VT of >0.5 was predictive of extubation failure in two ventricle patients but not for single ventricle patients.
- Therefore, VD/VT should be checked before attempting to extubate two ventricle patients and if higher than 0.5, extubation should not be attempted since the patient is likely to have an extubation failure.

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References