Size Limitation for Current Continuous Flow Pumps: How young can we go?

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How young can we go?

Patient-Device Size Mismatch
Size Mismatch Impacts Survival

Blume et al. Circulation 2006

% Survival vs Months After Implant

- Age >14 years (n=41)
- Age 10-14 years (n=39)
- Age <10 years (n=19)

Event: Death on VAD while waiting

*p=.006
*Censored at transplant.
Berlin Heart EXCOR® Pediatric

Image used with Berlin Heart permission
Temporal Distribution of Pump Exchange with Berlin Heart EXCOR® Pediatric at Texas Children’s Hospital

- Pump thrombus (w/ pump exchange)
  - Berlin ≈ 0.6 Event/Patient-Month
  - HMII/HW ≈ 0.06 Event/Patient-Year

120-fold difference
Adult Continuous-Flow VAD in Children

Berlin Heart EXCOR® Pediatric Pump Chart

Base image used with permission from Berlin Heart EXCOR® Information Booklet
Adult Continuous-Flow VAD in Children

Berlin Heart EXCOR® Pediatric Pump Chart

- ≥13 Kg (BSA ≥0.6)
- ≥40 Kg (BSA ≥1.3 m²)

Base image used with permission from Berlin Heart EXCOR® Information Booklet
Small LV Cavity
HeartWare® HVAD
Left Ventricular Coring Technique

Adachi et al. J Heart Lung Transplant. 2015;34:134-6
HeartWare® HVAD Sewing Ring

Adachi et al. J Heart Lung Transplant. 2015;34:134-6
Adequate LV Cavity – MV Replacement

All Images © 2014 Texas Children's Hospital
Adequate LV Cavity – MV Replacement

Bioprosthetic Valve
Adequate LV cavity – MV replacement
Inflow Angle
Acute Inflow Angle & Pump Thrombus

Taghavi et al. 2013
HeartWare® HVAD
Infra-diaphragmatic Placement Technique

Adachi et al. J Heart Lung Transplant. 2015;34:134-6
Infra-diaphragmatic Placement Technique

• Creation of a pump pocket by dividing the left hemi-diaphragm.

• Fixation of pump housing in the pocket.
Driveline
Driveline Tunneling

Pagani et al. 2013
Most kids severely malnourished, esp. with congenital heart disease

Becomes active on VAD
More Driveline Infection in Younger Patients


The diagram shows the number of driveline infection episodes per 100 patients over months after device implantation. The data is categorized by age groups:

- **< 50 years**
  - n=633, PSI=104
- **50 – 70 years**
  - n=1222, PSI=130
- **70+ years**
  - n=151, PSI=5

The graph indicates a higher incidence of infections in younger patients with a significant p-value of approximately 0.02.
Driveline Infection – Tearing Muscle

Connector 12 mm

Cable 4.2 mm
“Rectus-Sparing” Driveline Insertion

Image © 2014 Texas Children’s Hospital
Optimize RPM
How to Adjust VAD?
## LA Pressure Makes ICU Care Simple

<table>
<thead>
<tr>
<th>LAP ↑</th>
<th>CVP ↑</th>
<th>Over volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAP ↓</td>
<td>CVP ↓</td>
<td>Low volume</td>
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<tr>
<th>LAP ↓</th>
<th>CVP ↑</th>
<th>High rpm or RV failure</th>
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<tbody>
<tr>
<td>LAP ↑</td>
<td>CVP ↓</td>
<td>Low rpm</td>
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Avg. # of calls from ICU for the 1st night:

2.5 ➔ 0  \( (p<0.001) \)
# HeartWare® HVAD Experience in Children

<table>
<thead>
<tr>
<th>Institution</th>
<th>Patient No.</th>
<th>Age</th>
<th>Weight</th>
<th>BSA</th>
<th>Outcome</th>
<th>Support duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berlin</td>
<td>7</td>
<td>14 years (6 to 16)</td>
<td>36 Kg (17 to 79)</td>
<td>1.2 m² (0.7 to 2.0)</td>
<td>6 transplanted 1 on VAD</td>
<td>75 days (1 to 136)</td>
</tr>
<tr>
<td>Padova</td>
<td>3</td>
<td>14 yrs (11 to 15)</td>
<td>35 Kg (26 to 65)</td>
<td>1.2 m² (1.1 to 1.7)</td>
<td>All 3 transplanted</td>
<td>42 days (17 to 49)</td>
</tr>
<tr>
<td>Toronto</td>
<td>4</td>
<td>15 yrs (13 to 15)</td>
<td>58 Kg (47 to 80)</td>
<td>n/a</td>
<td>3 transplanted 1 on VAD</td>
<td>49 days (5 to 640)</td>
</tr>
<tr>
<td>Texas</td>
<td>12</td>
<td>10 yrs (5 to 17)</td>
<td>25 Kg (13 to 85)</td>
<td>1.0 m² (0.6 to 2.0)</td>
<td>4 transplanted 6 on VAD 1 died 1 recovered</td>
<td>150 days (30 to 1353)</td>
</tr>
</tbody>
</table>

Summary

• The use of adult VADs in children is challenging due to “patient-device size mismatch”.

• With appropriate technical modifications, adult VADs can safely be used even in small children.