THE USE of VENTRICULAR ASSIST DEVICES in CHILDREN: CURRENT OPTIONS & FUTURE TRENDS
• **ADULTS : VAD Better Accepted**
  
  – Technically easier
  – Fewer anatomical constraints
  – HTx is realistic possibility
  – Overall experience
Farrar, Hill, Pennington et al.
  - Cohort of 213 pts. in 35 centres
  - LVAD / RVAD / BiVAD or combo
  - 58% - 75% survival (all HTx)
  - Survival after HTx > 81%

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• CHILDREN : VAD Less Well Accepted
  – ? Technically difficult
  – ? Some anatomy unsuitable
  – Less experience
  – HTx less likely
  – Defined contraindications
  – ECMO for pulmonary dysfunction widely accepted
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....if Nil Contraindications....

Then Paediatric VAD SHOULD be Successful - and MIGHT be Better Than ECMO

VAD or ECMO

ADULTS or CHILDREN

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- VAD IS:
  - Simpler
  - Associated with less bleeding
  - Associated with fewer patient complications
  - Associated with fewer circuit complications
  - Less expensive
  - More children are weaned
    (but no more survive)

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• **Indications for VAD**
  – Unweanable from CPB
  – Weanable / weaned, but low cardiac output
  – Low cardiac output, not related to surgery
    » i.e.. recovery expected
  – Bridge to transplant
    » i.e.. recovery not expected

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• VAD or ECMO - that IS the question.....
  – either in OR or ICU
    • adequate oxygenation
    • no RV failure
    • no pulmonary hypertension
  – Three , = VAD
  – One  X  = ECMO
Does patient oxygenate?

- yes → Refractory RV failure?
  - yes → Refractory PHT?
    - yes → VAD
    - no → ECMO
  - no → ECMO
- no → ECMO

ECMO
### Ventricular Assist Devices in Children

**RCH VAD 1989-1997**

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norwood operation</td>
<td>10</td>
</tr>
<tr>
<td>Valve repair / replacement</td>
<td>9</td>
</tr>
<tr>
<td>Arterial switch operation</td>
<td>7</td>
</tr>
<tr>
<td>ALCAPA repair</td>
<td>5</td>
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<tr>
<td>Konno</td>
<td>3</td>
</tr>
<tr>
<td>Aortic root replacement</td>
<td>3</td>
</tr>
<tr>
<td>Supravalvar AS repair</td>
<td>2</td>
</tr>
<tr>
<td>HTx / HLTx</td>
<td>2</td>
</tr>
<tr>
<td>Bidirectional CP shunt</td>
<td>2</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>5</td>
</tr>
</tbody>
</table>

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SOTO et.al. 1997
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RCH VAD 1989-1997

- Univentricular vs biventricular repair $p = 0.29$
- Definitive vs palliative repair $p = 0.29$
- Age $< 1$ year $p = 0.13$
- Weight $< 6$ Kg $p = 0.35$

SOTO et.al. 1997
Ventricular Assist Devices in Children

- Berlin Heart
  - Paracorporeal, pneumatic
  - 10, 25, 30 ml stroke volume
  - Trileaflet polyurethane valves
Ventricular Assist Devices in Children

- Centrifugal pumps
  - Biomedicus, Sarns-Delphin, SJM-Lifstream
  - Non-occlusive
    » Preload and afterload dependant

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Ventricular Assist Devices in Children

- **Medos / HIA**
  - Paracorporeal, pneumatic
  - 9, 10, 22.5, 25 ml stroke volumes
  - 12 & 16 mm trileaflet polyurethane valves
  - Touch-screen drive unit
  - Transparent
  - Seamless joints
  - CAD optimized washout
<table>
<thead>
<tr>
<th>Location</th>
<th>Device</th>
<th>Author</th>
<th>Year</th>
<th>No. Pt’s</th>
<th>No. Weaned</th>
<th>No. Disch.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texas</td>
<td>Device</td>
<td>Scheinin</td>
<td>1994</td>
<td>9</td>
<td>77</td>
<td>55</td>
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<td>Berlin</td>
<td>Device</td>
<td>Hausdorf</td>
<td>1994</td>
<td>8</td>
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<tr>
<td>Sydney</td>
<td>Device</td>
<td>Costa</td>
<td>1995</td>
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<td>Device</td>
<td>Ishino</td>
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<td>14</td>
<td>71</td>
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<td>Pittsburgh</td>
<td>Device</td>
<td>Ashton</td>
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<td>9</td>
<td>89</td>
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<td>Tokyo</td>
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<td>Takano</td>
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<td>Melb’rne</td>
<td>Device</td>
<td>Soto</td>
<td>1997</td>
<td>48</td>
<td>71</td>
<td>46</td>
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<tr>
<td>Bergamo</td>
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<td>Glauber</td>
<td>1997</td>
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<td>100</td>
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<td>Boston</td>
<td>Device</td>
<td>Del Nido</td>
<td>1997</td>
<td>22</td>
<td>N/A</td>
<td>50</td>
</tr>
</tbody>
</table>

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RCH VAD experience: 1989-1997

- 48 patients (49 procedures)
- Median age: 3.5 months (2 days - 19 years)
- Median weight 4.7 kg (1.9 - 70 kg)
- 71% weaned

SOTO et al. 1997
Ventricular Assist Devices in Children

• **Kormos advocates**
  – Better selection & appropriate timing

<table>
<thead>
<tr>
<th>NOW</th>
<th>FUTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICU</td>
<td>Discharge</td>
</tr>
<tr>
<td>Organ recovery</td>
<td>Full recovery</td>
</tr>
<tr>
<td>Large device</td>
<td>Portable / implantable</td>
</tr>
<tr>
<td>Non ambulatory</td>
<td>School / work</td>
</tr>
<tr>
<td>Short term</td>
<td>Months / years</td>
</tr>
<tr>
<td>HTx ASAP</td>
<td>HTx when optimal</td>
</tr>
</tbody>
</table>

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The Future.......

- Biomedicus
  - use of a Cray super computer for Computational Fluid Dynamics analysis
  - ? decrease haemolysis by 25%
  - other information confidential

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The Future

- Biomedicus - Heinrich Heine University
  - design of servoregulation system for inlet
  - Aim: increase safety
    limit effects of NVP
The Future

- Abiomed
  - Research into paediatric version
  - 60 ml prime; 500 - 1500 ml/min. flow
  - Adjustable stroke volume 5 - 15 ml
  - Status: animal experiments
  - Issues: anticoagulation; haematology; pulsatility

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The Future

- **Jarvik**
  - Axial flow
  - 1 x 4 cm; <70 gm
  - Flows to 3 lpm @ 10,000rpm
  - Bearing design - blood washed
  - ? transcutaneous energy supply
  - LV apex - Descending aorta
  - Status: Animal testing
  - Issues: power supply; thrombus

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The Future......

- Pierce-Donachy
  - Aiming for <5 kg patients
  - Paracorporeal, pneumatic
  - ? need to alter 10mm bileaflet valves to lessen blood trauma
  - Improved flow patterns to facilitate
    » better washing
    » less thrombus

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The Future

- Mussivand - Univ. of Ottawa
- Transcutaneous energy transference
- Remotely programmable
- Totally implantable
- Status: prototype in animals
  paediatric size to come

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The Future.......

• Adults
  – Univ Utah centrifugal pump
  – Vienna Univ. sealless CP; ? implantable
  – Nimbus AxiPump
  – Medtronic Hemopump - new smaller size (<14FR)
  – Baylor Compact CP - uses ceramics & UHMW polyethelyne
  – DeBakey / NASA axial flow pump

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The Future......

• Adults (con’t)
  – Univ. Pittsburgh Artificial Heart Programme
    » Tiny Axial Flow pump in development