Mechanical Circulatory Support for the Failing Heart
FINANCIAL DISCLOSURE:
I have no actual or potential conflict of interest in relation to this program/presentation.
The Heart

- Average HR: 72 BPM
  - Beats 38,000,000 times a year
- Average SV: 82ml
  - 8193 L per day
- Cardiac output
  - CO = HR \times SV
  - Average CO: 5-6 L/m
- Cardiac Index
  - CI = CO/BSA
  - 2.5-4.0 L/min/m^2
Diastole

Resting and Filling
The scourge of heart disease
U.S. Population = 329,848,330 as of 11/26/2019
(4.3% of the world population)
Percentage breakdown of deaths attributable to cardiovascular disease (United States, 2016).
Chart 26-2. The 21 leading diagnoses for direct health expenditures, United States, average annual 2014 to 2015 (in billions of dollars).
### NYHA Classification

<table>
<thead>
<tr>
<th>Class I</th>
<th>No limitation of physical activity. Ordinary physical activity does not cause undue fatigue, palpitation, dyspnea, or angina.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class II</td>
<td>Slight limitation of physical activity. Patients are comfortable at rest. Ordinary physical activity results in fatigue, palpitation, dyspnea, or angina.</td>
</tr>
<tr>
<td>Class III</td>
<td>Marked limitation of physical activity. Patients are comfortable at rest. Less than ordinary activity causes fatigue, palpitation, dyspnea, or angina.</td>
</tr>
<tr>
<td>Class IV</td>
<td>Inability to carry on any physical activity without discomfort. Symptoms of heart failure or the angina syndrome may be present even at rest. If any physical activity is undertaken, discomfort is increased.</td>
</tr>
</tbody>
</table>
CHRISTIAAN BARNARD

First heart transplant:
December 3, 1967.
Patient - Louis Washkansky.

“We did not realize it was going to be such a big thing. There were no photographers at the operation.”
<table>
<thead>
<tr>
<th>Organ</th>
<th>Transplants Performed from July 1, 2017 through June 30, 2018</th>
<th>Total Transplants Performed through June 30, 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Adult</td>
<td>Pediatric</td>
</tr>
<tr>
<td>Heart</td>
<td>4,355</td>
<td>620</td>
</tr>
<tr>
<td>Heart-Lung</td>
<td>65</td>
<td>5</td>
</tr>
<tr>
<td>Lung</td>
<td>3,853</td>
<td>83</td>
</tr>
</tbody>
</table>
Adult and Pediatric Heart Transplants
Recipient Age Distribution by Era

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0-9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10-17</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-39</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40-59</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60-69</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>70+</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

p<0.0001

2019
ISHLT • INTERNATIONAL SOCIETY FOR HEART AND LUNG TRANSPLANTATION
Pediatric Heart Transplants
Recipient Age Distribution (Transplants: January 2005 – June 2018)
Adult and Pediatric Heart Transplants
Kaplan-Meier Survival by Age Group
(Transplants: January 1992 – June 2017)

Median survival (years):
- Adult = 11.5; Conditional = 13.9
- Pediatric = 18.1; Conditional = 22.3

p < 0.0001

Survival (%) vs. Years
Pediatric Heart Transplants

Median survival (years):
<1=24.5; 1-5=20.2; 6-10=15.9; 11-17=14.3

No pairwise comparisons were significant at p < 0.05 except 1-5 vs. 11-17.
Pediatric Heart Transplants
Functional Status of Surviving Recipients
(Follow-ups: January 2010 – June 2018)

- No play; does not get out of bed
- Often sleeping; play entirely limited to very passive activities
- In bed; needs assistance even for quiet play
- Mostly in bed; participates in quiet activities
- Can dress but lies around much of day; no active play; can take part in quiet play/activities
- Up and around, but minimal active play; keeps busy with quieter activities
- Both greater restriction of and less time spent in play activity
- Active, but tires more quickly
- Minor restrictions in physically strenuous activity
- Fully active, normal
Cardiac assist devices

BTT/DT
City's 1st Jarvik heart implanted

By Jeffery Fraser

The bleeding problem as minor, but offered no further
chest, Thomas O'Fair, hospital spokesman, described
details.

Surgeons removed Gaidosh's diseased heart and
implanted the mechanical device in a six-hour operation
which began around 4 p.m. yesterday. Hospital officials
said the implant was operating "beautifully."

Gaidosh had been transferred to Presbyterian four
weeks ago from West Penn Hospital. He had been
waiting 2 1/2 weeks for a heart transplant before he
became dangerously ill yesterday.

He suffered from idiopathic cardiomyopathy, a virus
of unknown origin which attacks and weakens the heart
muscles. His condition deteriorated yesterday and doc-
tors did not expect him to survive the day without a new
heart, a hospital spokesman said.

The artificial heart was implanted so Gaidosh could
survive long enough to undergo transplant surgery,
which doctors consider to be the best treatment for
irreversible heart disease.

As soon as an acceptable donor heart becomes
available, doctors would immediately transplant the
natural organ into Gaidosh, Chakurda said.

Doctors were not available for comment following the
implant. Assisting Griffith in surgery were Drs. Robert
Hardesty and Alfredo Trento, all of whom are members
of the University of Pittsburgh School of Medicine
faculty. After the implant, members of the surgical team
took part in a heart transplant at the hospital, sources
reported.

The implant marks the first time an artificial heart
was used by a Pittsburgh hospital.

Last Friday, surgeons at the Hershey Medical Center
implanted a mechanical heart in Anthony Mandia, a 44-
year-old Philadelphia recreation department worker. He
is reported to be in critical but stable condition as he be-
gins his second week with an artificial heart developed at
Pennsylvania State University.

Mandia's mechanical heart, which is similar to the
Jarvik-7, is also intended to be temporary. Both devices
are powered by air, which is pumped into the patient's
heart chambers through hoses that penetrate the
patient's chest.

Gaidosh was described as a large man who stands
about 6 feet, 5 inches tall and at times weighed as much
as 220 pounds. Because of his size, doctors said he would
not be competing with Mandia for the same type of donor
heart.

The Jarvik-7 and Penn State heart can be used as
permanent life-support systems, if necessary...

About 2 1/2 years ago, Gaidosh's heart condition forced
him to take a disability retirement from Pennsylvania State University.

Please see Heart, A2
1992 Gala
The Novacor® Left Ventricular Assist System
1st Gen. VADs

Heartmate XVE

Sintered Surface

Novacor LVAS
2nd Gen. VADs

- Continuous flow: rotary impeller
- Axial or centrifugal configuration
- Ceramic or jewel bearing support
- Smaller, simpler, improved battery life & better washing
HEARTMATE II

Rogers et al. NEJM 2017;376(5):451-60
HEARTMATE II
Bearing-less VADs (3rd Gen)

- Hydrodynamic bearing
  - As the rotor spins, fluid flow levitates the impeller creating a "blood cushion"
  - When the motor stops spinning, this "hydrodynamic bearing" disappears

- Ventracor® Ventrassist®
- Heartware® HVAD®
Overall Survival for patients with Continuous Flow isolated LVAD, n=18539

The Journal of Heart and Lung Transplantation, Vol 38, No 2, 2019

120 months: >100 patients
60 months: >2,500 patients

<table>
<thead>
<tr>
<th>Time post implant</th>
<th>% Survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 month</td>
<td>96%</td>
</tr>
<tr>
<td>3 months</td>
<td>92%</td>
</tr>
<tr>
<td>6 months</td>
<td>89%</td>
</tr>
<tr>
<td>12 months</td>
<td>83%</td>
</tr>
<tr>
<td>24 months</td>
<td>73%</td>
</tr>
<tr>
<td>36 months</td>
<td>63%</td>
</tr>
<tr>
<td>48 months</td>
<td>54%</td>
</tr>
<tr>
<td>60 months</td>
<td>46%</td>
</tr>
<tr>
<td>72 months</td>
<td>38%</td>
</tr>
</tbody>
</table>
Cardiac assist devices (Adverse events)
Distributions of Types of Device Malfunctions as a Percentage of the Total Malfunctions Seen in Kormos et al (2018)
Cardiac assist devices (Ped)
Berlin Heart Update

John Woodard, PhD
CTO
Pediatric Circulatory Support Devices for Infants and Small Children in U.S.

Berlin Heart
EXCOR® Pediatric Worldwide Experience

Clinical Experience

- More than 1,800 patients
- More than 164 pediatric heart centers in 37 countries
- 26 years implant experience
- Longest time on device > 3.5 years
A few of our UPMC patients
Total MCS Implants in UPMC System

1985 to Present

- 75 Pediatric
- 25 Imported
- 1265 Adult
Andrea McConaughy

Celebrating 20 Years!

8/21/96

14 Years Old
Diagnosed with Hypertrophic Cardiomyopathy

Waited 156 Days on an LVAD (Left Ventricular Assist Device) at UPMC (University of Pittsburgh Medical Center)

Went to a Playoff Penguin Hockey Game

1st person to leave hospital on an LVAD

Received Heart Transplant 8/21/96 at 3:30 PM

Because of my donor Michael & a 2nd chance at life...

Had Andrew 3/2002

Married Rob August 26, 2000

14 Years Old Now

Adopted Colin 12/2009

Colin is an Angel 2012

I've been parasailing, hiking, mountain biking, scuba diving, beaching.

Traveled to Canada, Italy, Iceland, England, France, Germany, Austria

Colin is an Angel 2012
Thank you for your attention