Pediatric Cardiology
Past, Present, and Future
My Journey

Korean Society of Circulation
51st Annual Scientific Meeting
October 11th -13th 2007
Seoul, Korea

Sang C. Park, M.D.
Professor of Pediatrics
University of Pittsburgh School of Medicine
The Beginning of Pediatric Cardiology
Surgical Progress in Pediatric Cardiology

- 1939  PDA Ligation (Gross)
- 1945  Coarctation Resection (Crawford)
- 1945  **Blalock-Taussig Shunt**
- 1950  Surgical Septectomy (Blalock - Hanlon)
- 1954  Pump Oxygenator (Gibbon)
- 1955  Open Bypass Heart Surgery (Lillihie)
- 1959  Senning Procedure
- 1964  Mustard Procedure
Surgical Progress in Pediatric Cardiology 2

- 1968 Human Heart Transplant (Barnard)
- 1971 Fontan Procedure
- 1975 Damus-Kaye-Stansel Procedure
- 1976 Arterial Switch Procedure (Jatene)
- 1976 Rastan-Konno Procedure
- 1981 Norwood Procedure
- 1981 Pediatric Heart Transplant
Dr Helen Taussig conceived an idea of creating PDA for cyanotic patients with TOF.

Initially contacted Dr Robert Gross at Harvard but he rebuked her.

Dr Afred Blalock reluctantly accepted the challenge and persuasion by Dr Taussig.
Vivien Thomas
Dr Blalock’s Lab assistant

Cardiac Surgery’s Invisible Man
Johns Hopkins Hospital
Mother of Pediatric Cardiology
Hopkins Reunion in 1976
Historical Management of TGA

- 1950: Blalock-Hanlon - surgical septectomy
- 1956: Baffes - partial venous routing
- 1959: Senning - atrial switch
- 1964: Mustard - atrial switch
- 1966: Rashkind - balloon atrial septostomy
- 1976: Jatene – arterial switch
Blalock-Hanlon Operation
# Surgical Atrial Septectomy Mortality

<table>
<thead>
<tr>
<th>Authors</th>
<th>Year</th>
<th>Mortality</th>
</tr>
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<tbody>
<tr>
<td>Blalock &amp; Hanlon</td>
<td>1950</td>
<td>75%</td>
</tr>
<tr>
<td>Cornell et al</td>
<td>1966</td>
<td>53%</td>
</tr>
<tr>
<td>Deverall et al</td>
<td>1969</td>
<td>45%</td>
</tr>
<tr>
<td>Baker et al</td>
<td>1971</td>
<td>40%</td>
</tr>
<tr>
<td>Clarkson et al</td>
<td>1972</td>
<td>29%</td>
</tr>
<tr>
<td>Behrendt et al</td>
<td>1975</td>
<td>21%</td>
</tr>
<tr>
<td>Herman et al</td>
<td>1975</td>
<td>15%</td>
</tr>
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</table>
Introduction of Pediatric Interventional Cardiac Catheterization

- Balloon Atrial Septostomy by Dr. William Rashkind
- Revolutionary change in management of infants with TGA
- Dramatic improvement in morbidity and mortality
## Results of Balloon Atrial Septostomy (Rashkind Procedure)

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Success</th>
<th>Compl /mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Venables et al</td>
<td>1970</td>
<td>73%</td>
<td>15%</td>
</tr>
<tr>
<td>Rashkind et al</td>
<td>1971</td>
<td>84%</td>
<td>-</td>
</tr>
<tr>
<td>Baker et al</td>
<td>1971</td>
<td>71%</td>
<td>9%</td>
</tr>
<tr>
<td>Neches et al</td>
<td>1973</td>
<td>89%</td>
<td>2%</td>
</tr>
<tr>
<td>Hawke et al</td>
<td>1974</td>
<td>62%</td>
<td>-</td>
</tr>
<tr>
<td>Rashkind et al</td>
<td>1974</td>
<td>87%</td>
<td>3%</td>
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Average 78%
Blade Atrial Septostomy Catheter

Conceived the idea in early 1970

Hand Made Model
Animal Experiment

Blade Septostomy only
Blade Balloon Septostomy
Clinical Case – Indianapolis, IN

- 3.5 yr old boy with DORV mitral atresia with PS, post Waterston shunt
- Restrictive inter-atrial opening with pulmonary edema and high fever
- Anesthesiologist and Surgeon were reluctant to perform surgery.
Clinical Trial of the Blade Catheter

Interatrial Mean Gradient
- Before 28 mmHg
- After 3 mmHg
Radiographic Change
after the Blade Atrial Septostomy

within 24 hours
Tiny Knife Inserted Through Vein Repairs Boy’s Heart

By DOLORES FREDRIECK
Press Science Writer

A X-mas Gift


A wonderful Christmas present to see Brian, bright-eyed, after surgery. He was so ill when I took him to the hospital,” said his mother, Debrah Chafin, 21, of Selma.

Brian, 3½, was a “blue baby.” He was also born without a mitral valve – a major heart valve between the upper and lower left chambers of his heart. His lower left chamber remains filled with heavy muscle and isn’t working normally to supply blood to his body.

Because of Brian’s illness, Dr. Sang C. Park, a children’s heart specialist at Children’s was flown to Indianapolis to perform surgery on Christmas Eve.

It was the second time ever Park’s new instrument – a tiny surgical knife, similar to a razor blade sliver – was used to open the right and left heart chambers of a young child. Because Park can’t find a manufacturer for his new instrument, he had to be called to do the surgery.

"Without surgery, Brian could have died. He was a very sick child and we needed to find a way to get the blood mixed between his right and left chambers,” said Dr. Donald Corder, a pediatric heart specialist at Indiana University’s Medical Center in Indianapolis.

Brian was hospitalized Nov. 23 and was very weak, with a high fever and severely congested lungs because blood wasn’t being properly supplied to the lungs.

During surgery, Park inserted his knife, which was collapsed and housed in a long tube (catheter) through a vein in Brian’s groin. Once the tube reached the heart, Park pulled a wire and opened the knife, following the progress of surgery on a “televised” fluoroscope that allowed doctors to see into the inner chambers of the heart.

In the one-hour procedure, Park cut a hole – about the size of a needle – between the upper right and left chambers to mix the blood flowing to Brian’s body.

Once the hole was cut, he retracted the blade and pulled the catheter from Brian’s veins.

Brian was spared open-chest surgery – which poses a serious risk to children already suffering serious heart problems.

Park’s instrument is a variation of a “balloon” instrument developed by William Raskind of Children’s Hospital in Philadelphia in 1966.

The death rate from open-chest surgery among children with conditions similar to Brian’s at one time was 40 percent.

The Raskind ‘balloon’ – which opens once it is inside the heart to pry open a hole to mix blood – cut the death rate to less than 1 percent, according to Dr. James Zuberbuhler, director of cardiology at Children’s Hospital here.

But Park said the Raskind instrument doesn’t always work in permanently opening the heart chambers. They would often close up again, requiring additional operations.

Babies are normally born with a hole in their hearts but it closes after birth, Zuberbuhler explained. It’s because their blood has to be mixed and their lungs aren’t working yet.

With children such as Brian, he said, “we try to reopen that hole. It’s usually temporary until they are strong enough for more extensive corrective surgery.”

But for some children, including Brian, there isn’t any corrective surgery yet developed to permanently correct the heart defect. However, there are several patients, some in their 30s, who don’t have repairable conditions but are “doing well” after undergoing the Raskind procedure.

Over the last eight years, Zuberbuhler said, 110 “balloon” procedures have been performed at Children’s Hospital. He estimates about 10 to 20 per cent of future cases may require the Park “knife” because of problems in opening up their chambers with the ‘balloon’.

Park first used his new instrument on a 7-month-old child. He said the procedure was successful but the child later died of an unrelated illness.

Brian first underwent surgery when he was three months old. He started turning blue and had difficulty breathing. Consequently, surgeons performed a Waterston shunt that bypassed his aorta to his pulmonary artery to get more blood to his lungs.

The Park catheter was used to mix the blood inside his heart chambers. Brian was discharged Jan. 7 and was back on the job as of yesterday, Tuesday, everything was “reported just fine.”

His recovery after Park’s procedure was described by Grod as “dramatic.” He said his fever went down, his lungs gradually improved over 10 days and he is home playing with his toys.

Dr. Sang Park and his tiny knife that repairs heart.
Development of the Blade Catheters

Hand Made

Professionally Made

3 Sizes
# Blade Atrial Septostomy

### Historic Progress

<table>
<thead>
<tr>
<th>Type</th>
<th>Initiated</th>
<th>Reported</th>
</tr>
</thead>
<tbody>
<tr>
<td>Studies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animal Experiments</td>
<td>1973</td>
<td>1975</td>
</tr>
<tr>
<td>Clinical Trial</td>
<td>1975</td>
<td>1978</td>
</tr>
<tr>
<td>Collaborative Clinical</td>
<td>1977</td>
<td>1982</td>
</tr>
<tr>
<td>Study</td>
<td></td>
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Collaborative Study

- Bakulev Institute, Moscow
- Hospital for Sick Children, Toronto
- Indiana University Hospital
- Texas Children’s Hospital, Houston, Texas
- Children’s Hospital of Pittsburgh

Dr Charles E Mullins
Texas Children’s Hospital
Blade Atrial Septostomy
Current Trend

- Less used for congenital heart disease as early infant surgery becomes routine.

- Other indications:
  Primary pulmonary hypertension to help the systemic output.
  To relieve pulmonary edema in patients on ECMO support.
  To relieve protein-losing enteropathy (PLE)
Complications
following Atrial Switch Procedures
(Senning or Mustard procedure)

- Systemic or pulmonary venous obstruction
- Atrial arrhythmia
- Tricuspid regurgitation
- Right ventricular dysfunction
Complications following Atrial Switch Procedures

- Right ventricular dysfunction
  
  Option: Heart transplant or
  
  *Conversion to Arterial Switch candidate that requires serial pulmonary artery banding procedures to train the left ventricle to serve as a systemic ventricle.*

  *Requiring multiple open chest procedures*
Percutaneously Adjustable Pulmonary artery Banding Device
Application of the Percutaneously Adjustable Pulmonary Artery Band
Adjustable Pulmonary Artery Band
Animal Experimentation
Adjustable PA Band
Animal Experimentation

<table>
<thead>
<tr>
<th>NO</th>
<th>Animal</th>
<th>Weight (kg) at OP</th>
<th>Observation Period (mo.)</th>
<th>Weight (kg) at Sacrifice</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lamb</td>
<td>4.1</td>
<td>10</td>
<td>50.8</td>
</tr>
<tr>
<td>2</td>
<td>Dog</td>
<td>3.2</td>
<td>6</td>
<td>5.4</td>
</tr>
<tr>
<td>3</td>
<td>Dog</td>
<td>2.9</td>
<td>23</td>
<td>8.2</td>
</tr>
</tbody>
</table>

10 months later

4.1 Kg

50.8 Kg
Adjustable Pulmonary Artery Band

Clinical Case 1

- Simple TGA
- 5 months - Senning Procedure
- 2.5 years - Reoperation for pulmonary venous obstruction
- 3 years - RV dysfunction and tricuspid regurgitation developed
- 4.5 years – Adjustable PA band was applied
- 5 years – Arterial switch procedure was done successfully.
Adjustable Pulmonary Artery Banding

Clinical Case 1

Dr Aldo Casneda performed
At Boston Children’s Hospital
On August 12, 1988
Late Result of the Adjustable PA Band

Warmest wishes for a Happy Holiday Season and a wonderful New Year.

Best wishes for 2007

Claudine Cava
(12/13/83)

Assistant Teacher

19 years later
Adjustable Pulmonary Artery Banding
Clinical Case 2

- TGA with small VSD
- 2.5 years – Developed severe RV dysfunction and tricuspid regurgitation
- 3 years – Adjustable PA band was applied
- 3.6 years – Arterial switch was performed successfully.
Adjustable Pulmonary Artery Banding
Clinical Case 2 in Pittsburgh

On January 18, 1989
At the Children’s Hospital of Pittsburgh
By Dr Ralph D Siewers
Adjustable Pulmonary Artery Band

- Animal experimentations and limited clinical trials were successful.

- However, no further clinical trial was possible DUE to
  
  Limited marketable value
  Stringent FDA regulatory process
  = Huge expenses
  Loss of interest in manufacturing the product
With Dr Taussig at AAP meeting in 1985, St Antonio, TX
Special Gathering in 1985

Alex Nadas
Jacqueline Noonan
Helen B Taussig
Bill Rashkind

Sub-Board of Pediatric Cardiology
of the American Board of Pediatrics

Twenty-fifth Anniversary Program
Saturday, October 19, 1985
The Four Seasons Hotel
555 South Alamo Street
San Antonio, Texas

Cocktail Reception at 6:30 p.m.
Dinner at 7:30 p.m.

PRESIDING: William F. Friedman, M.D., Chairman
Sub-Board of Pediatric Cardiology

Marlene Rabinovich
Donald Girod
Welton Gersony
Norman Talner
Two Legends in Pediatric Cardiology

Dr. Helen B Taussig
1898-1986

Dr. William J Rashkind
1922-1986
Some of my mentors and friends

Dr Richard D Rowe

Dr Alex Nadas

Dr Jerry Liebman & Dr Sam Kaplan

Dr Dan McNamara

Dr Chuck Mullins
Legends in Cardiac Morphology

Dr. Richard VanPraagh & Dr. Robert Anderson
London in 1985
Defect Closure

FDA approved
Stents for Congenital Heart Defects

- Premounted
  - 18, 30, 40, 50 mm
  - 19, 25, 29, 39, 59 mm
  - 3-10 mm

- 10, 16, 26, 36 mm

IntraStent™ DoubleStrut™ LD
Computer Assisted Navigation

- This CANav was developed to track the trajectory of an EM embedded needle and stylet relative to the position and orientation of 2D ultrasound image.
- It allows accurate and rapid navigation through multiple tissue planes to a 3 mm target.
Computer-Assisted Navigation: Large Animal Validation in Fetal Sheep

Use of the NDI Aurora magnetic generator, ultrasound imaging, and a custom needle containing a 0.4 mm diam NDI magnetic positioning coil (right hand) within the trocar of the needle, with sensor wires attached to the NDI system

NDI: Nothern Digital Inc
Novel Image Guided Technique

- Electromagnetic guided imaging technology
- Enables fetal intervention such as valvuloplasty and septosplasty
- Prevention of HLHS
We can now accurately diagnose congenital heart disease even in the fetus, and can surgically repair or palliate the heart defect in majority of cases.

We can also intervene the residual lesion by non surgical, transcatheter procedures.
Growing Number of Adult with Congenital Heart Disease

Congenitally Corrected TGA Mom 60 yrs  Daughter 32 yrs
TGA, post Senning  22 yrs
Future Challenges

- Increasing population of adults with residual heart disease – previously palliated
- Close surveillance of high-risk patients (post-Senning & Mustard procedure)
- Uncertain future of post-Fontan patients
- Timely protection of RV in patients with significant pulmonary regurgitation (post-TOF, post-truncus repair, & post-Ross group)
Heart / Lung Transplant
Ventricular Assist Device for Infant
Our Team and Collaborators

Bradley B. Keller, MD
Kimimasa Tobita, MD
Joe Tinney, BA
Steve Emery, MD

Fred Sherman, MD, MPH  CHP and MWH
Jacqueline Kreutzer, MD  CHP
Mick McCaffrey, MD  CHP
Harvey Borovetz, Ph.D.  Bioengineering, MIRM
Johnny Huard, Ph.D.  Orthopedics, MIRM
Bruno Peault, Ph.D.  Pediatrics, MIRM
Carter Ralphe, M.D.  Pediatric Cardiology
Guy Salama, Ph.D.  Cell Physiol. and Bio.
Sanjeev Shroff, Ph.D.  Bioengineering, MIRM
David Vorp, Ph.D.  Surgery, MIRM
Bill Wagner, Ph.D.  Surgery, MIRM
Jim Antaki, Ph.D.  Bioengineering, CMU
Takeo Kanade, Ph.D.  Robotics, CMU
Jim Osborn, M.S.  Robotics, CMU

Li Jun Liu, MD
Kelly Clause, BS

CASurgica, Inc., BlueBelt Technologies, Inc.
Ension, Inc., Launch Point Technologies, Inc.
Gene Therapy is already in Clinical Trials
Our Wishes may come True someday!
Pediatric Cardiology Staff
At the Children’s Hospital of Pittsburgh
Final Plea

- Have an *Innovative Idea*

- Have a firm *Commitment* to Work Hard to Achieve the Goal

- Have steadfast *Ambition*, purely for the benefit of the patients

- *Never* Give Up
Why are we climbing Mt Everest?
No Pain = No Gain!

Potala Temple, Lhasa, Tibet
Machu Picchu, Peru
Carlo, Egypt
Beijing, China
Final Take Home Message

- Innovative Idea
- Commitment
- Ambition
- Never Give Up
Final Take Home Message

- Innovative Idea
- Commitment
- Ambition
- Never Give Up

Yes, you can!
Thank You !
Best Wishes to All!
ALWAYS EXCITING IN PITTSBURGH...