Introduction to Extracorporal Life Support

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Extracorporeal Life Support Terminology

ECMO – extracorporeal support using cardiopulmonary bypass pumping systems with a membrane oxygenator in place, i.e., extracorporeal membrane oxygenation

ECLS – any form of extracorporeal cardiovascular support. Does not require a membrane oxygenator or pump in place, but may have either or both.

Examples: LVAD, ECMO, Berlin Heart

Extracorporeal Life Support Terminology

Rapid Deployment ECMO (ECPR) – use of a modified rapidly primed ECMO circuit for coding patients

It takes a lot of people to run an ECMO Program

- RNs & RTs are the backbone of most ECMO programs – specialty training & certification
- Perfusion prime conventional ECMO & ECLS experts

Extracorporeal Membrane Oxygenation

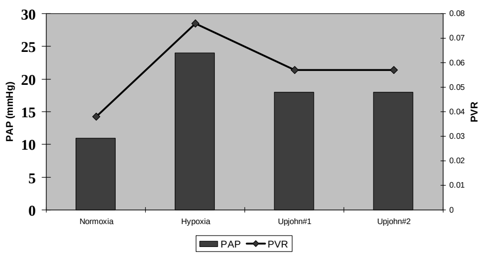
- **The ECMO procedure uses a modified cardiopulmonary bypass circuit to provide pulmonary &/or cardiac support for a prolonged period of time.**
- **ECMO provides *"time"* for lung &/or heart rest, so that recovery can occur - ??**

Heparin: Protective Effects

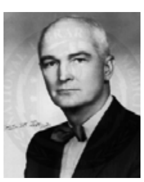
- Reduces production of Thromboxane in animal models of gram negative sepsis/shock
- Reduces endothelin-1 production with a simultaneous increase in nitric oxide formation
- Inhibit platelet-activating factor-induced pulmonary edema
- Suppress the increased vascular permeability induced by histamine, bradykinin, & PGE_2

Inhibition of Hypoxic Pulmonary Hypertension by Heparins of Differing *In Vitro* Antiproliferative Potency

Thompson, et al, Am J Resp Critical Care Med: 149, 1512-1517, 1994



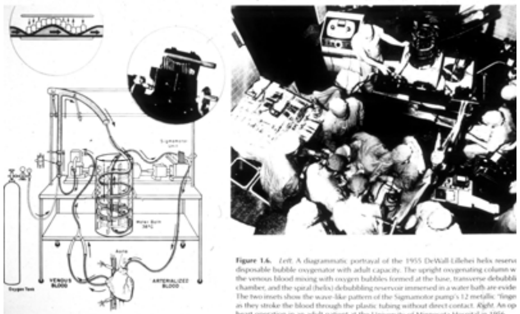
History of Cardiovascular Surgery



- ***1931 Dr. John H. Gibbons, Jr.***
  - Set at the bedside of a women with massive pulmonary embolism … "what she needs is a machine to oxygenate her blood while they attempt to remove the emboli"

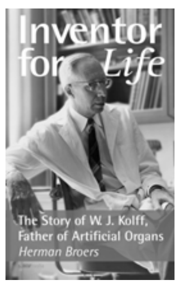
1953 Dr. John H. Gibbons, Jr.-

1st Successful open-heart operation using extracorporeal support

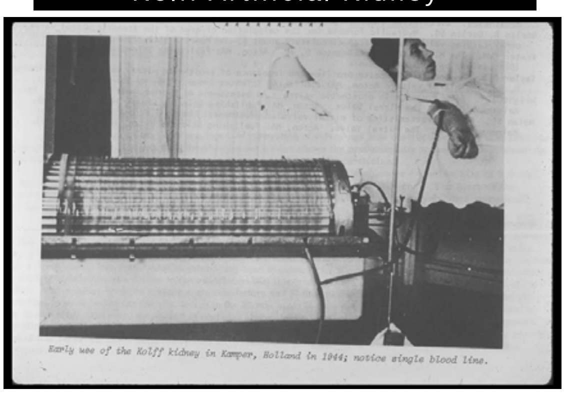


History of Extracorporeal Life Support

- ***1944 - Kolff & Berk***
  - First to note that oxygen could be transported across a membrane into blood
  - Noted that blood became oxygenated when it passed through the cellophane chambers of the artifical kidney they were designing



Kolff Artificial Kidney

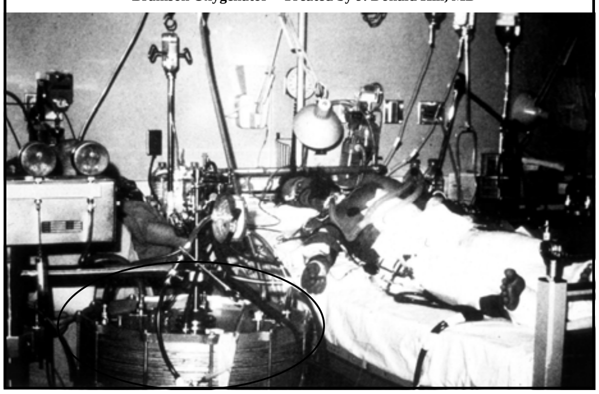


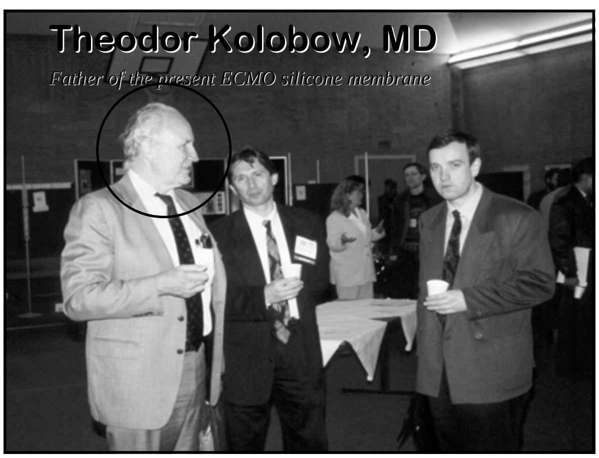
History of Extracorporeal Life Support

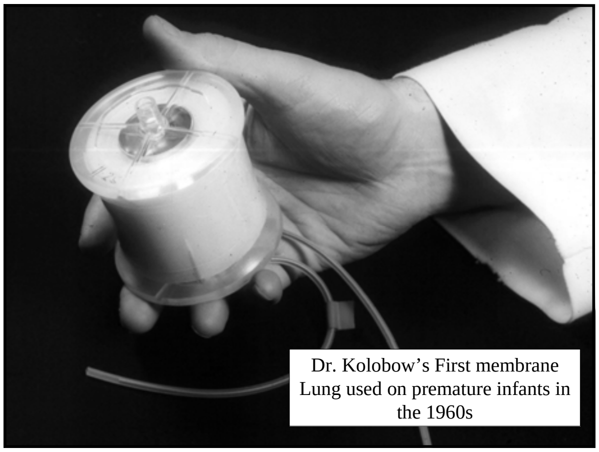
- ***1956 - Clowes***
  - 1st ethylcellulose membrane lung
  - Although the membrane was too large to for practical use, Clowe's work opened the field of research into this area for cardiopulmonary bypass & ECLS

1st ECMO Survivor 1971

Bramson Oxygenator – Treated by J. Donald Hill, MD







Dr. Kolobow's First membrane Lung used on premature infants in the 1960s

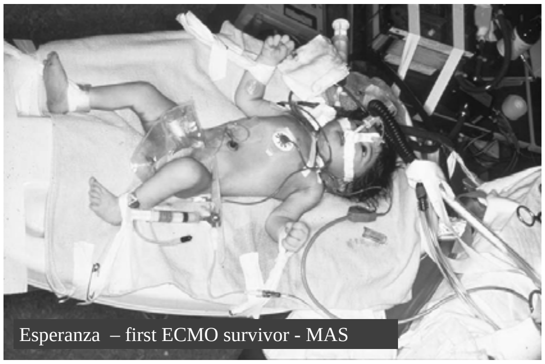
Kolobow's First Membrane Lung

- Used at CNMC in 1960's to treat premature infants
- A-V Method using the umbilical vessels
- Good respiratory support, but all died of IVH

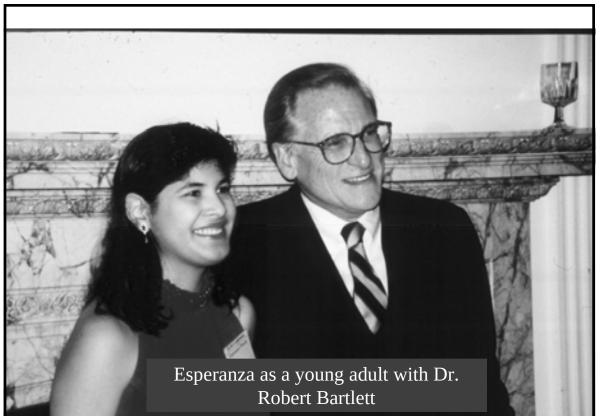
Unpublished data: Gordon B. Avery, MD, PhD

Extracorporeal Membrane Oxygenation: "the Artificial Placenta"

- **1960s: Rashkind, White, Dorson, & Avery, all studied ECMO in premature animals &/or humans**
- **1976, 1st Neonatal Survivor reported by Bartlett & colleagues, *term infant with Meconium Aspiration Syndrome***



Esperanza – first ECMO survivor - MAS



Esperanza as a young adult with Dr. Robert Bartlett

Membrane Lungs Used Today: Same Kolobow Design

ECLS Registry Report
International Summary
July, 2007

Extracorporeal Life Support Organization
1327 Jones Drive, Suite 101
Ann Arbor, MI 48105

Overall Outcomes

	Total Patients	Survived ECLS		Survived to DC or Transfer	
Neonatal					
Respiratory	21,509	18,306	85%	16,344	76%
Cardiac	3,110	1,810	58%	1,176	38%
ECPR	311	196	63%	119	38%
Pediatric					
Respiratory	3,578	2,291	64%	1,997	56%
Cardiac	3,858	2,345	61%	1,736	45%
ECPR	606	313	52%	235	39%
Adult					
Respiratory	1,332	777	58%	676	51%
Cardiac	765	348	45%	252	33%
ECPR	243	92	38%	67	28%
Total	35,312	26,478	75%	22,602	64%

Centers

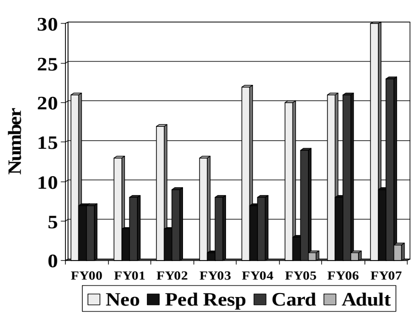
ELSO Outcome Data

	Cases/Year	Survival
Neonatal	750	62%
Pediatric Respiratory	225	55%
Adult	100	48%
Cardiac	622	44%

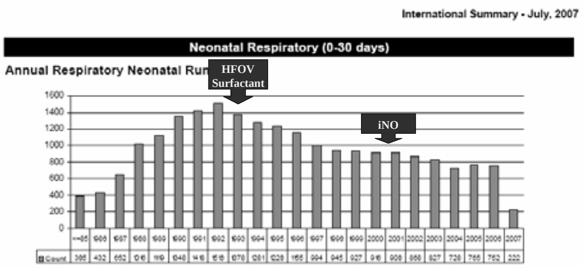
****Survival based on 2006 & 2007 data***

CNMC ECMO Patients

Years 2000 - 2007

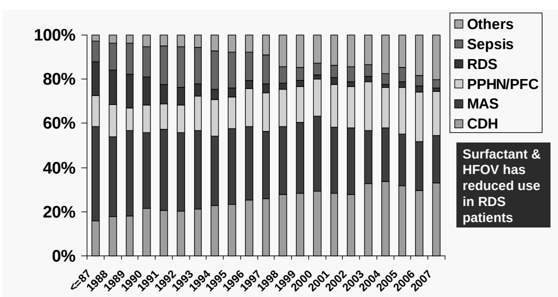


Neonatal Respiratory Cases



July 2007

Neonatal Diagnosis as Percent of Total Neonatal Patients

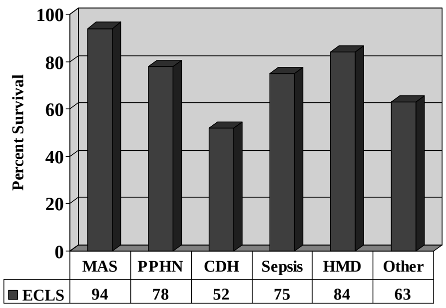


Neonatal Respiratory
N=21,509
Survival = 76%

July 2007

Neonatal ECMO Survival

1987-2007



ECMO: Diagnoses Comparisons

	MAS	PPHN	CDH
Age on ECMO (Days)	2.00	2.86	2.27
Time on ECMO (hrs)	138	159	266
BW (kg)	3.0	3.15	2.89
GA	38	37	37
Apgar (1/5 min)	4/6	6/7	4/6
FIO2	.96	.95	.95
PIP/PEEP	34/3	32/3	32/3
MAP	16	14	15
Pre-pH	7.00	7.18	7.08
Pre-pCO2	44	44	58
Pre-pO2	45	43	39
Pre-Sats (%)	65	61	56

Data from ELSO Registry, Years 2000-05

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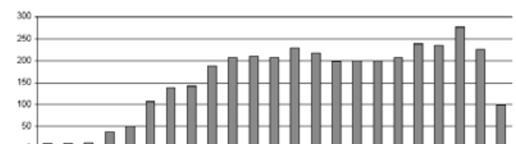
Pediatric Respiratory Cases

International Summary - July, 2007

Pediatric Respiratory (> 30 days and < 18 years)

Annual Respiratory Pediatric Runs



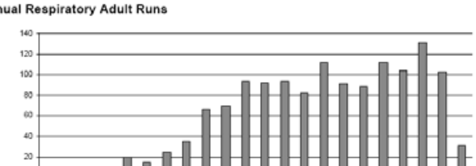
	<=85	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Count	10	13	12	38	50	108	139	142	188	207	210	207	229	215	198	199	200	207	237	236	276	225	98

Adult Respiratory Cases

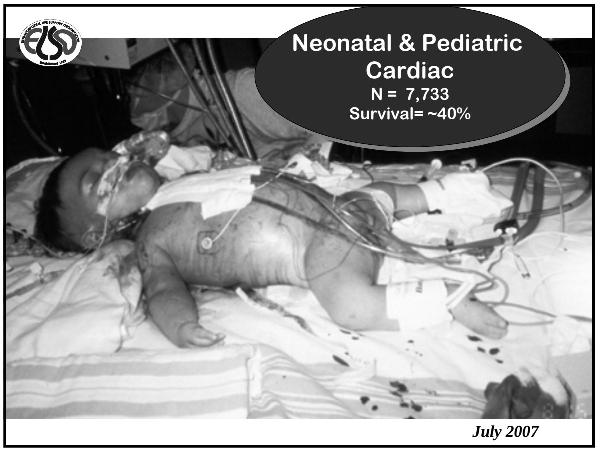
International Summary - July, 2007

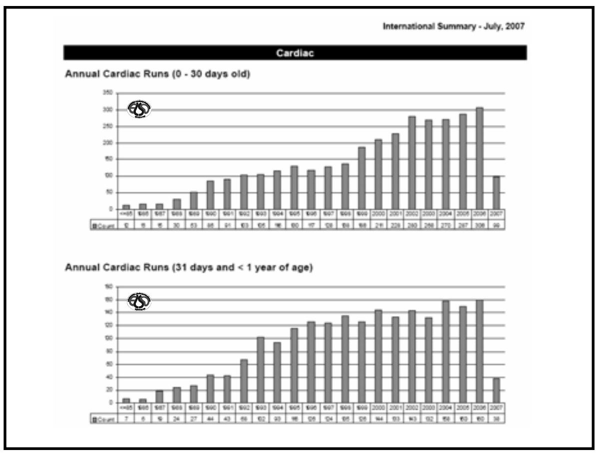
Adult Respiratory (18 years and over)

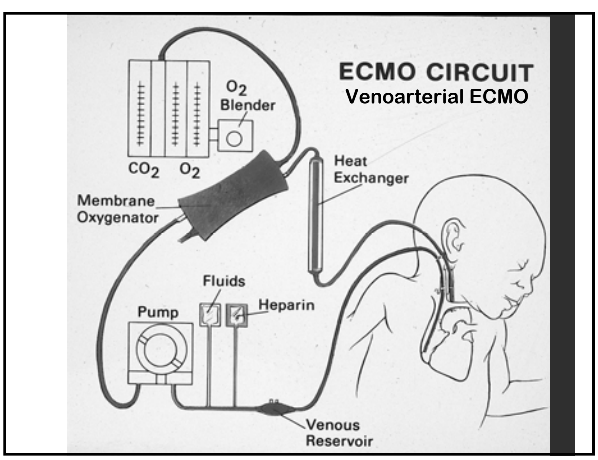
Annual Respiratory Adult Runs



	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Count	1	1	5	2	20	15	25	35	67	70	93	92	93	82	112	91	88	112	104	131	103	31

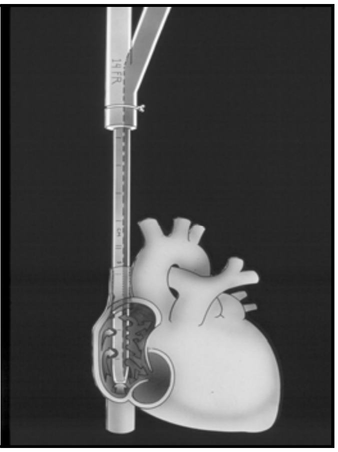

Neonatal & Pediatric
Cardiac
N = 7,733
Survival= ~40%
July 2007


International Summary - July, 2007
Cardiac
Annual Cardiac Runs (0 - 30 days old)
Annual Cardiac Runs (31 days and < 1 year of age)


ECMO CIRCUIT
Venoarterial ECMO
O2
Blender
CO2
O2
Heat
Exchanger
Membrane
Oxygenator
Fluids
Heparin
Pump
Venous
Reservoir

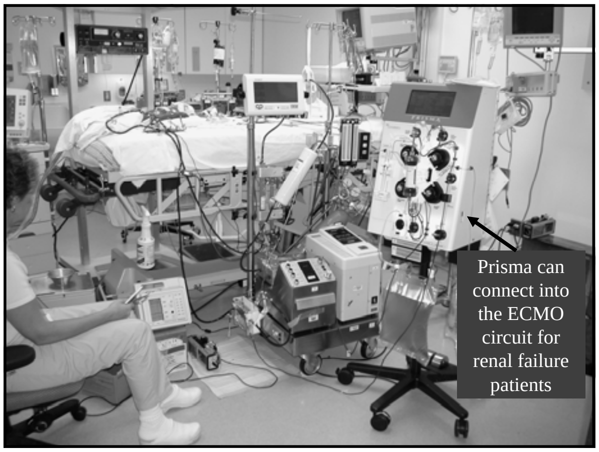
Venovenous ECMO

- Limitations
  - **Hypotension**
  - **Recirculation resulting in Hypoxia**

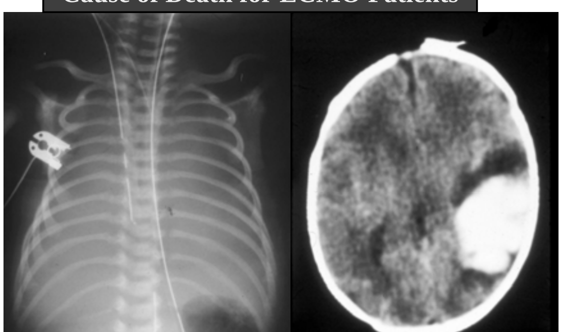


Cannulation: Done at the Patient's Bedside

In newborns, the initial bypass Goal is to take over 60% of the cardiac output with the ECMO circuit ~ 120mL/kg/min



Cause of Death for ECMO Patients



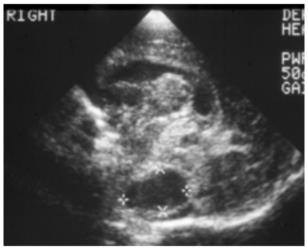
Most Neonatal Deaths are related to ICH, exception the CDH patient; Pediatric both ICH & Pulmonary failure; Cardiac ICH & cardiac failure

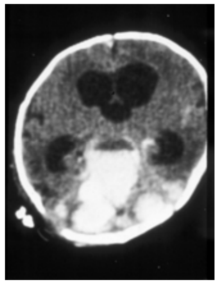
Risk Factors for ICH on ECMO Patients

- **Pre-ECMO Events**
  - Hypoxia
  - Asphyxia
  - Hypotension
  - Hyperventilation
  - Permissive hypercapnia ?
- **ECMO**
  - Altered blood vascular flow patterns
  - Heparinization

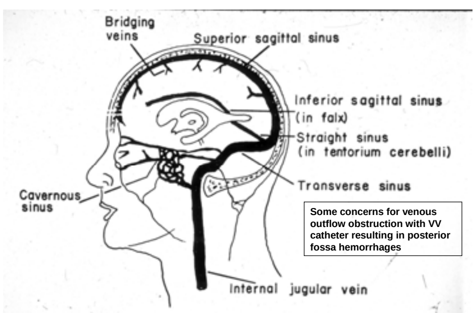
Venous Congestion Caused by Venous Catheter:

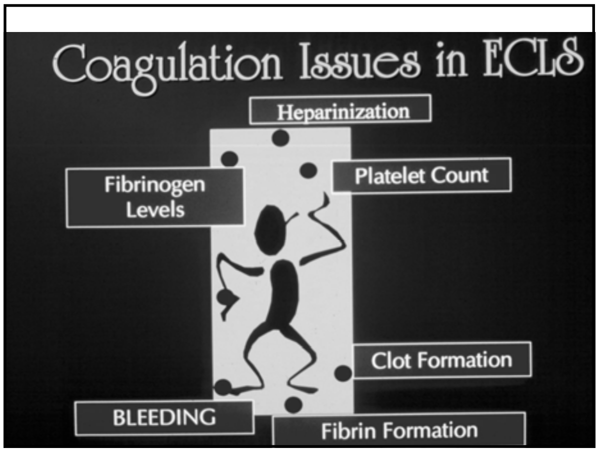
Risk for Posterior Fossa Hemorrhage





Venous Outflow





Bedside testing using Activated Clotting Time (ACT)

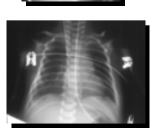
ACT Parameters: 1st Day

Risk Factors	ACT (seconds)
Low/None	190-200
High	180-190
Bleeding	160-170
Surgery	150-160

Typical VA ECMO Run:

ECMO DAY 1 - 3	ECMO Flow 60-80%
ECMO DAY 2 - 3	ECMO Flow 50-60%
ECMO DAY 4 - 8	ECMO Flow 10-30%

Idling Flow 10%

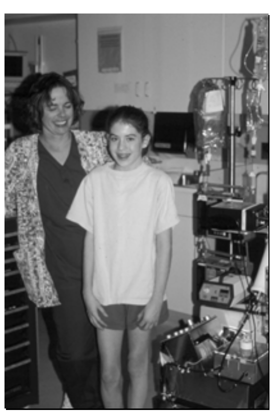


ECLS – Long-term outcome

Long-term Follow-up

- At age 2 years, Bayley exams showed 65% predicted normal, 20% suspect, 15% delayed,
- At age 5 years, mean IQ normal, but 38% concern for learning disability
- At age 12-13 years, exercise tolerance testing, shows decreased exercise tolerance compared to normal controls, but most children were active in sports and doing well
- Follow-up at puberty has shown normal development, but study small (n=19)

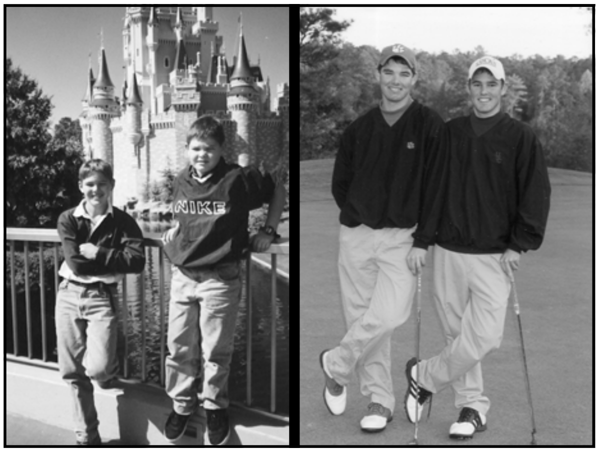
1st CDH Survivor at CNMC

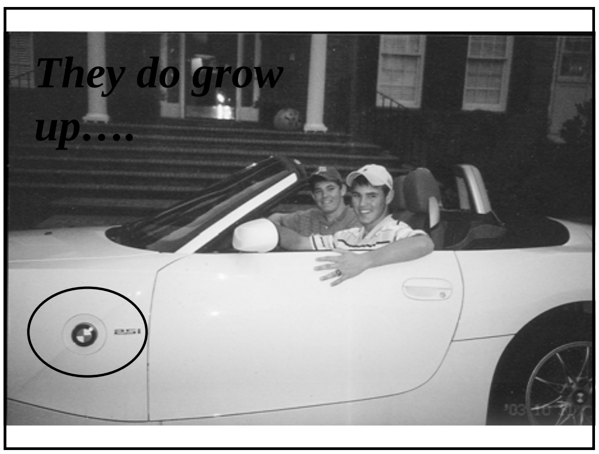


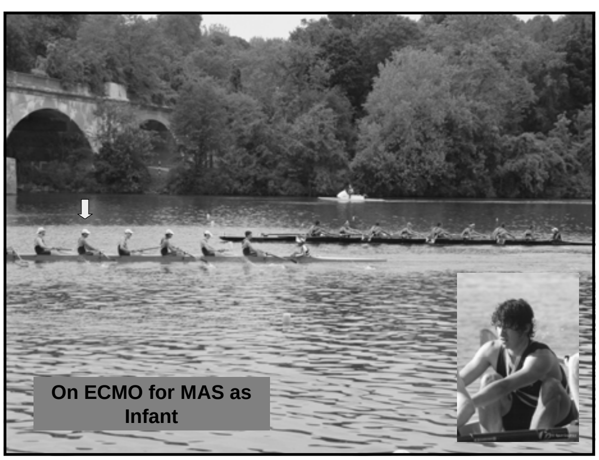
…started

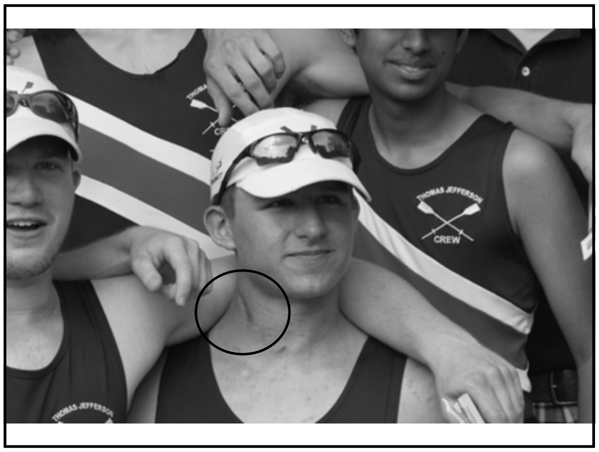
Medical School this Year

…first 34 week GBS sepsis survivor


NIKE


They do grow
up….


On ECMO for MAS as
Infant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CREW


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Keystone, Colorado
February 24-28, 2008
www.ECMOmeeting.com