

# CONGENITAL CARDIOLOGY TODAY

News and Information for Pediatric and Congenital Cardiovascular Physicians and Surgeons

Vol. 5 / Issue 6  
June 2007  
International Edition

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## NONINVASIVE MONITORING OF CARDIAC OUTPUT: BENEFITS OF NIRS TECHNOLOGY

By George M. Hoffman, MD and Nancy S. Ghanayem, MD

While adequate organ perfusion is a primary goal of supportive and therapeutic intensive care, numerous studies show that cellular oxygen deficit (dysoxia or shock) is under-recognized, under-diagnosed and under-treated. Significantly impaired organ blood flow frequently occurs in patients who are normotensive, but who have reduced or maldistributed cardiac output. Indicators of oxygen supply-demand relationships such as venous oximetry (SvO<sub>2</sub>) can significantly improve the diagnosis of shock states, and can reduce the incidence and severity of multi-organ system dysfunction and mortality when utilized to guide resuscitation and support.

There is a narrow temporal window for diagnosis and intervention in shock states before organ injury occurs. Multiple studies suggest early detection of inadequate oxygen delivery and appropriate goal-directed interventions can reduce complications of shock, while delayed diagnosis and treatment is ineffective. According to research presented in Pediatric Cardiac Surgery Annals,[1] authors indicate that current clinical descriptors of cardiac output and circulatory function that lead to shock are inadequate, and provide incomplete and sometimes misleading information, especially in children. Without a clear picture of the cardiovascular status, the physician's ability to assess systemic and regional tissue oxygenation, to intervene early in shock, and to limit resulting complications is impaired.

Noninvasive monitors are becoming increasingly useful in children for the assessment of cerebral and somatic (i.e., organ bed, skeletal muscle tissue) tissue oxygenation, providing a more comprehensive clinical picture that allows early recognition and treatment of circulatory abnormalities that lead to multiorgan dysfunction.

One of the most exciting developments is a novel multi-site, non-invasive monitor for the brain and body using near-infrared spectroscopy, or NIRS.

### Limitations of Conventional Monitoring Techniques

A closer look at the mechanism of shock sheds some light on the limitations of conventional monitoring techniques. The body reflexively responds to shock by redistributing blood flow to preserve the brain and heart, leaving other tissue beds – typically kidneys, liver, and intestines – at increased risk for silent ischemia.[2-4] In pediatric patients, shock is typically characterized by low cardiac output and very high systemic vascular resistance.[5] If regional vascular resistance is sufficiently high, ischemic damage may occur to specific organ beds, even in the presence of normal global oxygen economy and blood pressure.

Conventional noninvasive assessment tools reliably measure heart rate, blood pressure, arterial oxygen saturation, and that data can be used to approximate some of the determinants of cardiac output and oxygen delivery. But because these are systemic metrics, they may be late indicators of shock. Other techniques such as indirect calorimetry, alveolar gas analysis, bio-impedance, and pulse contour and Doppler studies add more information about cardiac output and systemic oxygenation, but can still leave clinicians uncertain about the adequacy of regional perfusion. They are also more prone to influencing factors (e.g. physiology, environment, staff skills), making the data less reliable. The result may be an inaccurate picture of the clinical status of critically ill infants and children, since even experienced physicians may not recognize patterns of clinical parameters indicative of the early stages of shock.

*Continued on Page 3*

## SPECIAL COMMENTARY

## ALLEN TOWER: 'THE CASE IS ALTERED'

By Michael J. Tynan and Shakeel A. Qureshi, MD

All interventionists involved with children know the NuMED name and the company's products. Most of us will know the name of the company President, Allen J. Tower, and many will have met him. However, those involved in other fields of the speciality may know little about NuMED and Allen Tower and know less about how important the products are to paediatric cardiology.

At present Allen, and thus the NuMED company, is in dispute with the United States Government and it appears that there is the possibility that Allen could be sentenced to a term in prison. This would be a disaster for children with congenital heart disease. NuMED is the only manufacturer specialising in equipment for catheter interventions for babies and children.

Allen Tower has always been an innovator in our field. He was the manufacturer who collaborated with Dr. Berman in the development of the balloon angiographic catheter. This catheter, now manufactured by another company, is for many, the mainstay of diagnostic angiocardiology.

When, in the mid 1980s he started NuMED Inc, in his home territory of upstate New York, he turned to paediatric cardiologists and asked what it was that we needed. That has been his philosophy throughout. Anyone with a need for new or modified catheters has been listened to and where ever possible he has tried to satisfy that need.

Usually his interpretation of our ideas has resulted in a superior product than we had



Allen J. Tower

***"The esteem in which Allen is held by we interventionists was shown when, in 2003, he was the recipient of the 'Lifetime Achievement Award' at the 7th Pediatric Interventional Cardiac Symposium."***

envisaged. First of the NuMED 'inventions' was the co-axial angioplasty and valvuloplasty balloon catheter, the TyShak. This allowed the production of very low profile balloons with very rapid inflation and deflation times. These are beneficial for all children but are ideal when it comes to interventions in newborn babies and small infants. The ease of introduction of relatively large balloon catheters in small arteries and veins and the short time that the balloon was obstructing blood flow means shorter procedure times, less circulatory disturbance and less vascular damage. These catheters are used by most paediatric interventionists worldwide, so any interruption in their supply would have a negative impact on the outcome for babies and children in the USA but its effect would be worldwide.

His other innovations are too numerous to detail, but some should be mentioned. Together with Philipp Bonhoeffer he developed both the 'Multitrack' catheter system used by many interventionists. They have also produced a catheter implantable pulmonary valve which is under study in several countries. An integral component of this system is another NuMED innovation, a stent for children developed with John Cheatham, the CP stent with a special balloon for its stable implantation, the BiB balloon. A development of the stent is the Covered CP stent which has been life saving for a number of patients. All this equipment has approval in Europe but not in the USA. And it is the supply of the BiB balloon, the CP and covered CP stents, on a compassionate basis, which lit the fuse for the initial FDA investigation.

The esteem in which Allen is held by we interventionists was shown when, in 2003,

he was the recipient of the 'Lifetime Achievement Award' at the 7th Pediatric Interventional Cardiac Symposium. To date, he is the only recipient of this award who does not have a medical qualification.

Allen has been unstinting with his time and resources for the improvement of our equipment and thus our ability to do a better job for our patients. He has also been very generous in his support of paediatric cardiology meetings and has made many donations to his local community.

Allen has built up a team of highly skilled and very dedicated workers in Hopkinton, but there is no doubt that he is the driving force behind NuMED and the whole paediatric community, workers, patients and parents will suffer if he is incarcerated. In England during the reign of Queen Elizabeth I, a gentleman was accused of holding a Catholic Mass, which was illegal. His lawyer Edmund Plowden (1518-1585) proved that it had been the work of a provocateur, not a priest. Plowden said 'The case is altered, no priest, no Mass.' Now, for Allen 'The case is altered,' but with no easy way out.

We do not have detailed knowledge of the full legal case but it appears that his problems may be, to a great extent, due to his willingness to help physicians and their patients. Perhaps the bureaucratic errors, for that is what they appear to be from this side of the Atlantic, were as much to do with healthcare professionals such as us, as with Allen. In which case we have a duty to support him. We urge you to go to <http://www.thepetitionsite.com/takeaction/250006502> and sign the petition in his support.

~CCT~

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Venous oximetry monitoring is a more accurate reflection of oxygen metabolism[6] in neonates than conventional monitoring tools, but poses a risk of injury and/or infection during placement and removal of fiberoptic indwelling catheters. Further, since SvO<sub>2</sub> is a global measure, it does not reliably detect maldistribution of blood flow or regional tissue dysoxia.

### The Mechanics and Use of NIRS Technology

NIRS technology eliminates the technical challenges and risks associated with invasive SvO<sub>2</sub> monitoring, and identifies regional perfusion abnormalities. Noninvasive light-emitting diodes (LEDs), that transmit near-infrared light to the tissue bed at a depth of about 2.5-3cm, and corresponding photodetectors are placed on the area of the brain or body to be assessed.

Like pulse oximeters, NIRS monitors utilizes the differential absorption of two or more wavelengths of light by hemoglobin as it associates and disassociates with oxygen. Unlike pulse oximetry, NIRS techniques measure the average hemoglobin saturation in a field of tissue, with arterial, capillary, and venous components. Over a wide range of conditions, the amount of red and infrared absorption by hemoglobin in a field of tissue is most closely related to the regional venous blood saturation. NIRS devices which provide spatial resolution and algorithms calibrated from a 25%;75% arterial:venous blood ratio thus can provide a continuous, non-invasive approximation of tissue oxyhemoglobin saturation in a field of tissue 2-3cm beneath the skin. These measures allow early and rapid identification of inadequate tissue oxygenation, and allow guided interventions before hemodynamic changes further destabilize critically ill pediatric patients.

When used on two or more sites such as over the brain and a peripheral organ bed, NIRS (through cerebral/somatic oximetry) provides a real-time window on oxygen economy in two distinct tissue beds and a comparative model of regional tissue oxyhemoglobin saturation.[7-8] An accurate assessment of cerebral and somatic tissue oxygenation in critically ill patients enables timely intervention to prevent or minimize the often irreversible damage caused by dysoxia. Studies which capture continuous, real-time monitoring of cerebral and regional tissue oxyhemoglobin saturation support the advantages of NIRS in reducing postoperative morbidities.

### Multi-Site rSO<sub>2</sub> Monitoring

Our institution has evaluated a novel monitoring strategy that employs NIRS to measure regional oxygen saturation (rSO<sub>2</sub>).

***“NIRS technology eliminates the technical challenges and risks associated with invasive SvO<sub>2</sub> monitoring, and identifies regional perfusion abnormalities.”***

Initially designed as a cerebral monitoring tool—and used successfully for that purpose in published studies of adults undergoing cardiac surgery for early detection of cerebral blood flow derangements—the INVOS System (Somanetics Corporation, Troy, MI) comprises a multi-detector system (up to four probes) that enables concurrent and continuous cerebral and regional oxygen saturation monitoring.

Somanetics' NIRS device received U.S. FDA approval for trends monitoring of rSO<sub>2</sub> in the brain and skeletal muscle tissue. Clinical data in both children and adults support a link between cerebral rSO<sub>2</sub> values less than 40% to 50%, or a deviation from baseline of more than 20%, and hypoxic-ischemic neural injury.[9-12]

Our hospital initially used the Somanetics device, which originally came with two probes, to monitor pediatric patients for cerebral oxygen derangements. Since infants and neonates have limited geography on their foreheads, we chose to place the second probe over the flank. Our intent was to assess blood flow and regional blood oxygenation in a tissue bed with circulatory controls very different from the brain, such as the kidney. We found this multi-site approach provided us with a unique window on blood flow throughout the body, and we've integrated it into our standard care protocol.

Autoregulatory mechanisms help maintain cerebral blood flow and brain oxygenation at relatively constant levels over a wide range of physiologic conditions. The kidney, on the other hand, is a high-flow, low-extraction organ in which renovascular resistance is under strong sympathetic control. The sympathetic stress response to shock triggers a dramatic increase in vascular resistance within the kidney, with accompanying circulatory impairment and heightened risk of ischemic organ damage. Direct, real-time, dual-site monitoring of cerebral and peri-renal perfusion clearly demonstrates the profound differences in the oxygenation of these organ



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beds as the patient's circulatory status changes.

Based on our experiences with the cerebral-somatic oximeter at Children's Hospital of Wisconsin, we find it reliable in showing the adequacy of site-specific perfusion and the maldistribution of blood flow. As such, we believe it's today's best non-invasive method for detection of shock; providing unique information for a more complete patient assessment. It is appropriate for use on any patient at risk for shock, and we presently use it on patients undergoing operative procedures or cardiac catheterization, as well as patients admitted to the neonatal and pediatric intensive care units. Because it is entirely non-invasive, NIRS has also been useful during triage assessment within the emergency room and for assessment of inpatients not admitted to critical care units.

**Important Findings**

The ability to monitor regional oxygen saturation at multiple sites is an important strength of the cerebral/somatic oximeter using NIRS. Trending correlation studies of cerebral and somatic oximetry performed in neonates after the Norwood procedure—the first stage surgical palliation of Hypoplastic Left Heart Syndrome—have demonstrated parallel changes in tissue oxyhemoglobin saturation (rSO<sub>2</sub>) and SvO<sub>2</sub> (Figure 1).[13] Prolonged low rSO<sub>2</sub> is more predictive of ischemic neurologic damage that traditional assessments used currently during surgery and in the ICU.[14]

Dual-site monitoring of rSO<sub>2</sub> enables an accurate prediction of the mixed SvO<sub>2</sub>. In fact, calculation of the SvO<sub>2</sub> based on the linear combination of cerebral and somatic NIRS monitoring yields a closer approximation of the SvO<sub>2</sub> than does either regional measure alone (Figure 2).[15] Furthermore, although inter-

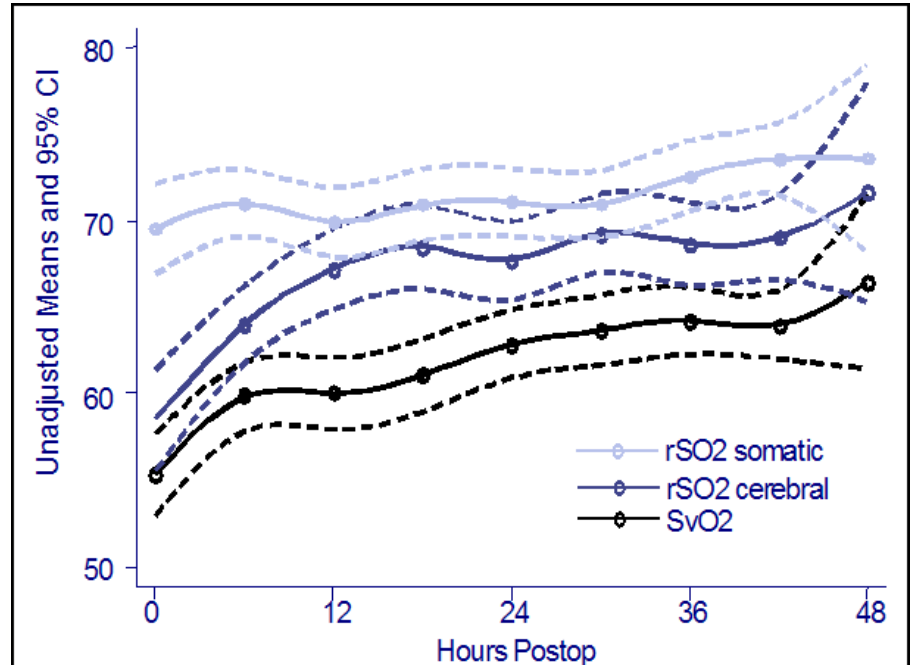


Figure 1. SvO<sub>2</sub> parallels changes in cerebral and somatic rSO<sub>2</sub> in postoperative neonates.

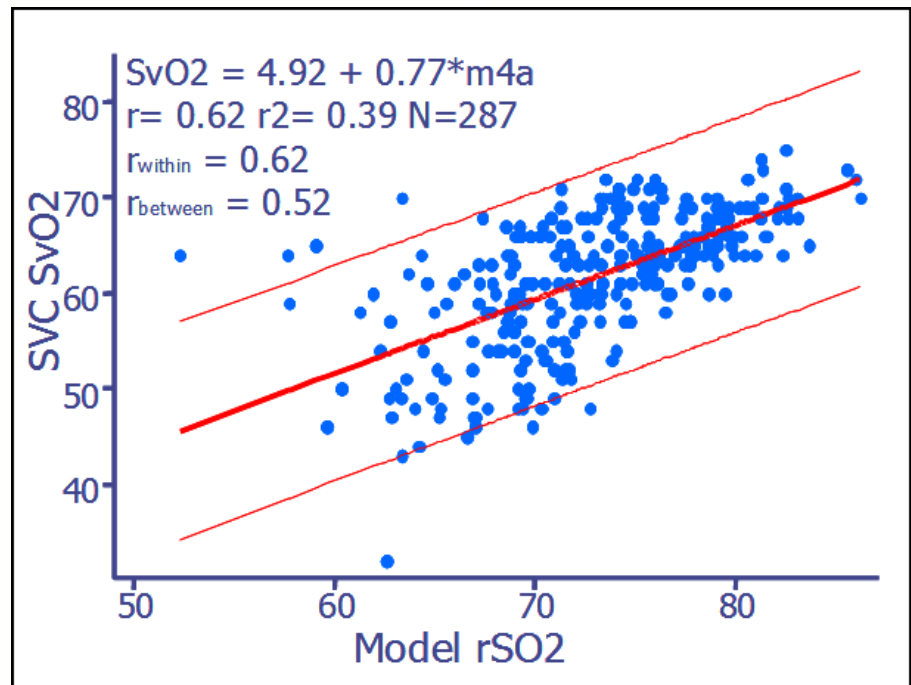


Figure 2. A linear combination of cerebral and somatic rSO<sub>2</sub> provided a better approximation of SvO<sub>2</sub> than either alone.



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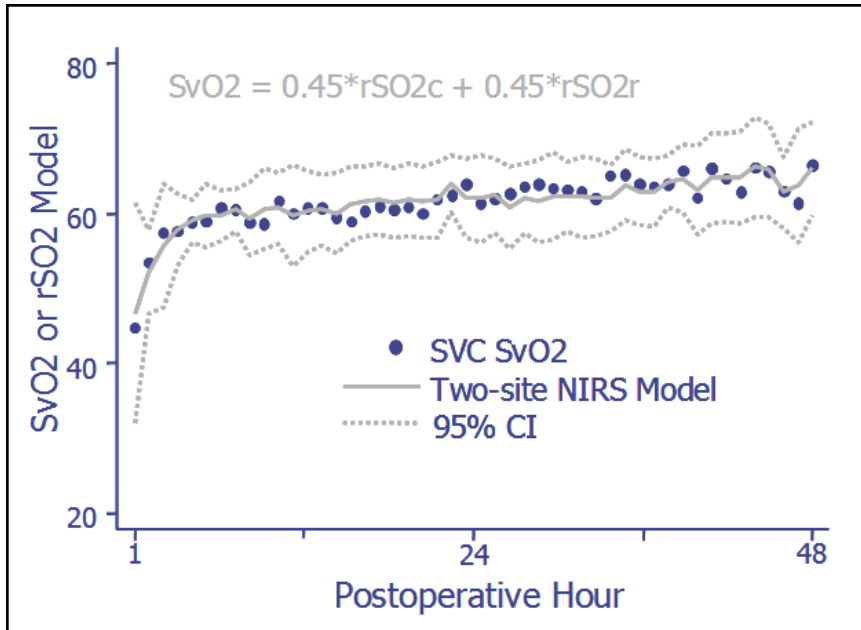


Figure 3. The two-site NIRS model shows very good prediction of SvO<sub>2</sub> for within-patient trends.

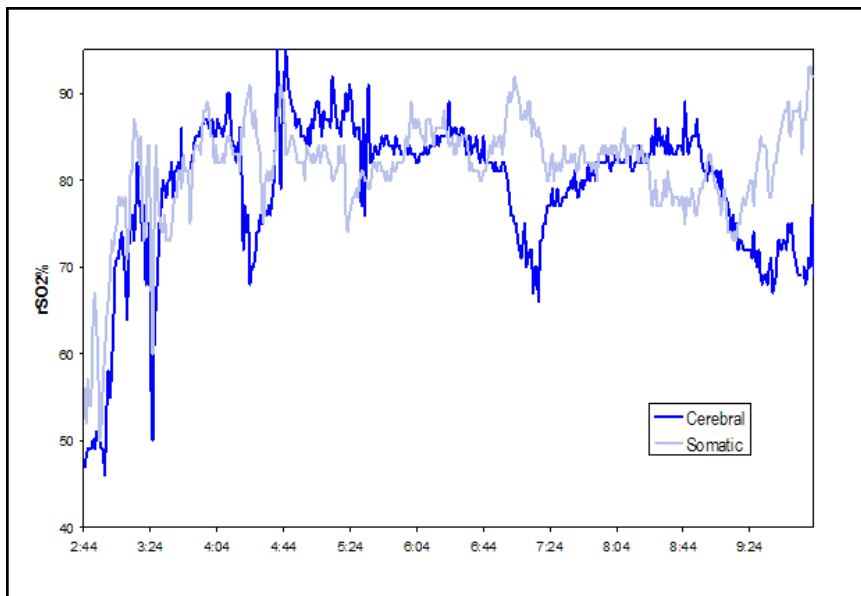


Figure 4. Two-site NIRS trends from a patient undergoing resuscitation from hypovolemic/septic shock. Early aggressive resuscitation with fluid and epinephrine to normal regional rSO<sub>2</sub> values restored urine output. The effect of changes in pCO<sub>2</sub> on cerebral blood flow are evident at 0700. The mirror changes in cerebral and somatic rSO<sub>2</sub> suggest that total cardiac output was relatively limited but that the distribution changed.

patient variability is high, within-patient trends of two-site cerebral/somatic oximeter correlate closely with SvO<sub>2</sub> values (Figure 3).[15]

Figure 4 depicts the output of two-site cerebral/somatic oximeter using NIRS in a patient undergoing resuscitation from hypovolemic/septic shock.[1] Data trends underscore the correlation between somatic and cerebral rSO<sub>2</sub> and SvO<sub>2</sub> modeling. Early detection of shock allows for aggressive resuscitative measures with fluid and epinephrine, restoring rSO<sub>2</sub> values to normal levels.

**Conclusion**

Multi-site NIRS is feasible technology that plays an important role in monitoring critically ill patients at risk for circulatory derangements. Cerebral-somatic oximetry with NIRS should not replace conventional monitoring, but rather serve as an important adjunct that allows for continuous, earlier assessment of perfusion abnormalities. This permits therapeutic interventions to maintain adequate systemic perfusion and oxygen economy, and thereby reduce ischemia-related complications with associated organ failure and mortality.

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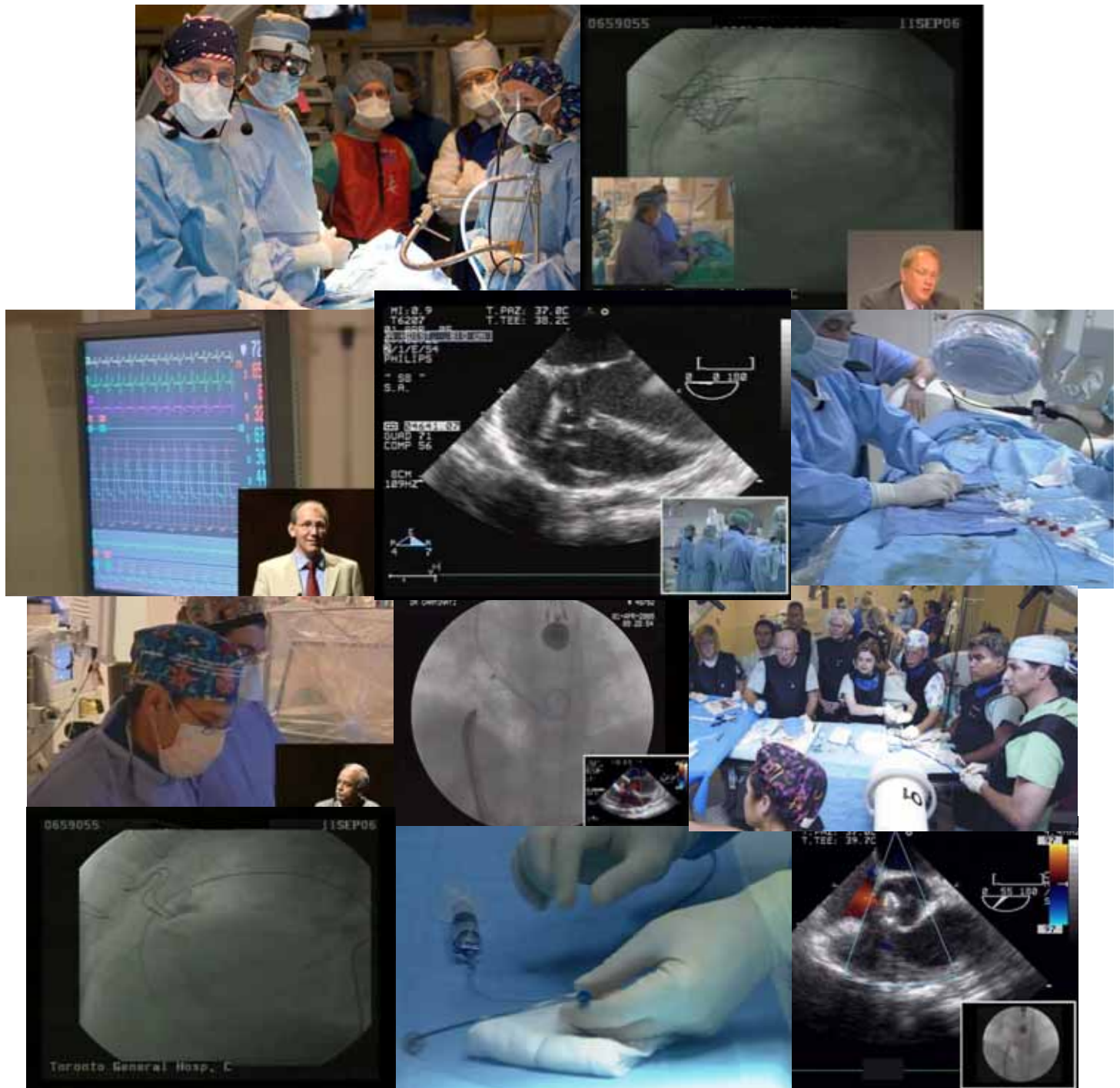
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# HIGHLIGHTS FROM CARDIOLOGY 2007 – 10TH ANNUAL UPDATE ON PEDIATRIC CARDIOVASCULAR DISEASE

By Gil Wernovsky, MD

to learn from such a distinguished faculty and insightful group of course attendees, and we look forward to planning

care, fiscal responsibility and patient safety.

### Featured Research, Posters and Abstracts

From over 100 initially submitted, 65 abstracts were presented in two separate poster sessions from 40 institutions and 16 countries. Those that have not been previously published as abstracts are included later in this electronic supplement. The top three abstracts were presented as oral presentations by Kirsten Odegard of Children's Hospital, Boston ("Prospective longitudinal study of coagulation profiles in children with hypoplastic left heart syndrome from stage I through Fontan completion"), John Costello, also of Children's Hospital, Boston ("A systematic initiative to reduce blood stream infections in a pediatric cardiac intensive care unit") and Jon Kaufman from Children's Hospital of Denver/University of Colorado Health Science Center ("Correlation of abdominal oximetry with gastric tonometry: measurement of splanchnic oxygenation in neonates and infants with congenital heart disease"). In a very close vote by the entire faculty, the 4th Annual Outstanding Investigator Award was given to Dr. Kaufman and his colleagues.

Surgical innovations and practices in complex congenital heart disease were the focus of many of the posters. William Douglas (Lexington) presented information on an adjustable flow device for systemic artery to pulmonary artery shunts; Daniel Nento (Cleveland) presented improved outcomes in side-to-



The Cardiac Center at The Children's Hospital of Philadelphia hosted our 10th Annual Postgraduate Course at Disney's Yacht and Beach Club Resorts in sunny Orlando, Florida from February 21st-25th, 2007. Over 750 professionals and exhibitors gathered from around the globe to hear late breaking research, discuss controversial topics, review current practices and enjoy each other's company and insight. I was privileged

our 11th meeting next year in Scottsdale, Arizona.

What distinguishes this postgraduate from other excellent subspecialty meetings is the multidisciplinary group of course attendees. Physicians made up approximately half of the attendees, and included representation from all disciplines involved in the care of children with heart disease including: cardiologists, intensivists, surgeons, anesthesiologists, neonatologists and maternal fetal specialists. Approximately 50 physicians were fellows, residents or medical students. The remaining attendees included: advanced practice, operating room, catheterization lab and bedside nurses; sonographers; physicians assistants; respiratory therapists; and the largest group of perfusionists ever present at our meeting (48). Finally, a growing number of administrators continue to partner with front-line care givers in sessions devoted to delivery of





side (as opposed to end-to-side) technique in augmenting the ascending aorta in patients with hypoplastic left heart syndrome and Martin Zahorec (Bratislava) discussed the role for arterial duct closure in patients undergoing modified Blalock-Taussig shunt placement. The most challenging aspects of hypoplastic left heart syndrome and other univentricular heart disease were tackled with researchers showing several "outcome challenges." Areas covered included results of the Fontan palliation in children with trisomy 21 (Francis Moga, Minneapolis); catheter intervention for hypoplastic left heart syndrome with intact atrial septum (Chris Petit – Philadelphia), neurodevelopmental abnormalities overall (Anke Furck, Kiel), and the role that inherent coagulation abnormalities may play – even before any surgery – in patients with a univentricular heart (Nina Hakáčová, Bratislava). Lindsay Ryerson from the University of Michigan discussed the role of heparin therapy in protein losing enteropathy. Wasim Khan from Rainbow Babies described the physiological responses to exercise in children after the Fontan Operation, while the group from The Children's Hospital of Philadelphia utilized magnetic resonance imaging to study the effects of exercise on power loss after Fontan palliation. Collaboration between institutions was evident in Duke's efforts (presented by Maura Catherine Baldwin) to validate the follow-up program reported by The Children's Hospital of Wisconsin.

High fidelity simulators were shown to significantly improve cardiac center nurses' confidence in critical scenarios – an important support in times when rapid education and skills development is an issue for many centers (Robertta Hales, Philadelphia). Simulators were also shown to improve time for cardiac care teams to initiate extracorporeal membrane oxygenation (Cecilia St. George-Hyslop, Toronto). Resuscitation scientists also showed improvements in cardiopulmonary resuscitation techniques with use of a Voice Advisory Manikin system (Robert Sutton, Philadelphia).

Administrators and others taking a "50,000 foot view" of our care systems were benefited by a cost analysis of various mechanical support techniques as a bridge to heart transplantation (Andrei Morgan, Newcastle-Upon-Tyne), and the role that virtual regionalization models (Shabib Alhadheri, Syracuse) can play in improving outcomes when providers can be mobile but care can't be given under one roof. Sonographers and their colleagues had their interests focused on the roles for the discharge echocardiogram in improving outcomes (Christa Barlow, Cincinnati), and on the correlation between pulmonary vein Doppler signals and left atrial pressures (Sarah Gelehrter, Ann Arbor).

The field of electrophysiology was investigated in five abstracts. Aimee Malpass and colleagues from the University of Mississippi showed that amiodarone is both safe and effective in the acute management of supraventricular tachycardia in neonates. The clinical and electrophysiologic characteristics of both left and right ventricular tachycardia in children with structurally normal hearts were presented by Nelangi Pinto from The Children's Hospital of Philadelphia. Armando Alfaro and colleagues from Costa Rica showed that ventricular single lead pacing is an effective and safe method to maintain atrioventricular synchrony in third degree atrioventricular block.

Fetal cardiology was also strongly represented. Paul Brooks studied the effects of antenatal diagnosis of pulmonary atresia with an intact ventricular septum and found that while there was an improvement in systemic oxygenation prior to the initiation of prostaglandin E1, there was no overall improvement in mortality. Kirsten Dummer reported from the Boston experience that prenatal diagnosis of tetralogy of Fallot is highly accurate and that it is unusual to see progression to pulmonary atresia. Anita Szwaast from The Children's Hospital of Philadelphia demonstrated that maternal hyperoxygenation in the fetus with hypoplastic left heart syndrome is a safe and useful procedure to assess the pulmonary vasculature. Lisa Wise-Faberowski from the University of Colorado presented two abstracts utilizing a chronic hypoxia model in the developing brain to describe the use of magnetic resonance spectroscopy, as well as the effects of isoflurane.

Several abstracts focused on patient care from the nursing perspective, and included a report from Stanford that emphasized the importance of continued nursing educational sessions as a mechanism to improve professional autonomy and enhances patient safety, a similar point made by the nursing staff at The Children's Hospital of Philadelphia who routinely utilize the benefits of an educational resource nurse in the training of new cardiac intensive care nurses. Nursing and safety interventions were the highlight of many posters. Pharmacist-led pediatric medication safety teams (Jennifer Costello, Newark – winner of the outstanding nursing poster award), patient safety checklists at handovers (Deanna Edwards, Little Rock), and targeted mining of administrative databases for cardiovascular medication errors (Diana Alexander, Baltimore) were all shown to play roles in improving outcomes and safety for our most vulnerable patients. Sternotomy pain control augmentation with continuous local anesthetic infusions (Marilyn Torres, Miami), and nurse coordinated programs to improve enteral feeding success (Britt Elin Fredriksen, Oslo) drew comments and crowds in the busy session.



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In the featured research session, Andrew Redington (Toronto) ‘teased’ the audience with the study design of a randomized trial of aspirin and warfarin for patients with a Fontan circulation, and then told us that the results were still being analyzed....undoubtedly to garner an invitation to speak next year! Scott Bradley and colleagues from the Medical University of South Carolina performed a prospective cohort study on neonates with midline arch reconstruction (both for Hypoplastic Left Heart Syndrome and biventricular repairs), and reported a surprisingly high incidence of swallowing dysfunction, aspiration, and vocal cord injury. Barry Byrne from the University of Florida in Gainesville reported on exciting work into both the mechanism and treatment for inherited cardiomyopathies. Finally, Lynn Mahoney updated the group on the exciting work being conducted by the Pediatric Heart Network, sponsored by the National Heart, Lung and Blood Institute. See [www.pediatricheartnetwork.com](http://www.pediatricheartnetwork.com) for more details.

**Plenary Sessions**

The opening session on cardiopulmonary resuscitation featured experts in the fields of resuscitation science, nursing, cardiac intensive care and pediatric cardiac anesthesia. Vinay Nadkarni (Philadelphia) and Mary Fran Hazinski (Nashville) reviewed the current state of the art and the science behind the American Heart Association guidelines for pediatric resuscitation. Sarah Tabbutt (Philadelphia) gave excellent examples of why these guidelines are not always relevant to postoperative patients with congenital cardiac disease, and Ravi Thiagarajan (Boston) showed us some practical and convincing work on the improvement gained with a simulation program for staff in an intensive care unit. George Hoffman (Milwaukee) gave a comprehensive

review of the literature on post-resuscitation brain protection, and speculated on the relevance to children following cardiac surgery. Finally, the day ended with a spirited debate between Tom Spray (Philadelphia) and Jim Tweddell (Milwaukee) on the risks and benefits of open cardiac massage during resuscitation. Dr. Spray’s video comparing the size of his hand to that of a typical neonatal heart was quite visually “revealing” of the difficulties of direct massage in small neonates.

Two plenary sessions were given back to back on the second day of the conference, covering coronary artery disease in children and double outlet right ventricle. Jack Rome (Philadelphia) moderated the session on coronary artery disease in children, which began with Alan Friedman (New Haven) reviewing normal coronary anatomy followed by a discussion on the anatomy, hemodynamics, and clinical characteristics of abnormalities of coronary origin (including anomalous coronary artery from the pulmonary trunk and intramural coronary arteries), as well as coronary fistulae, and Kawasaki Disease. Michele Frommelt (Milwaukee) discussed how to best image the coronary arteries by echocardiography which was followed by Paul Weinberg (Philadelphia) showing superb anatomic specimens of the previously discussed anomalies. Mark Fogel and Jeff Hellinger (Philadelphia) subsequently advocated use of cardiac magnetic



imaging and computerized tomographic imaging to delineate these anomalies showing beautiful images, including the “fly-thru” technique of three dimensional imaging. David Nykanen (Orlando) illustrated the continued necessity for coronary angiography as an additional imaging modality, especially in evaluation and potential intervention of several coronary anomalies. Paul Stephens (Philadelphia) discussed the determinants of



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coronary flow, including how best to assess myocardial perfusion abnormalities. The session concluded with the debate on whether children with an anomalous origin of a coronary artery from the 'wrong' sinus of Valsalva should have surgery. Tim Feltes (Columbus) argued that only those who have evidence of ischemia should have surgery, as the true risk of a sudden catastrophic event is unknown; Jim Tweddell countered that surgery should occur irrespective of ischemia, since there is an increased risk of ischemia and sudden death. By a show of hands, the winner by a small margin was Tim Feltes.

The plenary session discussing double outlet right ventricle was moderated by Jack Rychik (Philadelphia). Professor Robert Anderson (London) convinced the audience that double outlet right ventricle is not a single isolated defect, such as tetralogy of Fallot, but rather is a series of different relationships between the great arteries, where both are supported by the anatomic right ventricle, the ventricular septal defect being the most important feature. Paul Weinberg followed showing beautiful specimens, including those with mitral atresia and straddling of the mitral valve, as well as various relationships of the ventricular septal defect to the great vessels. Meryl Cohen (Philadelphia) reviewed the key goals of the echocardiographic evaluation: the relationship of the ventricular septum to the great vessels, the number of ventricular septal defects, the relationship of the great arteries to each other; the relative size of the ventricles, and the potential pathway from the left ventricle to great vessels through the ventricular septal defect. This point was re-emphasized by Pedro del Nido (Boston) showing that the creation of a three dimensional baffle from the left ventricle to the aorta or the pulmonary artery is the greatest surgical challenge in these patients, and advocated for three dimensional imaging as a routine part of the preoperative assessment.

For a change of pace, a 4th plenary session - "Improving Safety for Cardiovascular Patients" - proved to be an exciting testament to the work being done by so many colleagues in our field to improve the safety of our care delivery systems.

Peter Laussen (Boston) led off the session with a wonderful overview entitled "Changing culture for continuous quality improvement." Defining moments were described that required novel efforts to improve governance, management, and effect culture change. Dr. Laussen showed the central role of nursing leadership in promoting culture change and in leading to improved consistency in patient care. Adequate support for culture change can involve significant financial resources and attending physician accountability was emphasized. We heard about Children's Hospital in Boston's Program For Patient Safety And Quality, the importance of audits to measuring and improving performance, and the imperative for leadership to promote a balance of work and personal goals.

Karen Harrington (Montreal) gave an absolutely outstanding presentation "How may we improve communication during patient handover?" The audience was treated to a broad review with ideas of safety as a "dynamic non-event", communication breakdowns as a major cause of sentinel events, and that a knock-on effect of working hour restrictions is an increased need for handovers and an imperative to do them well. Dr. Harrington implored our field to recognize handovers as both a transfer of responsibility and accountability as well as information, and that improvements should be driven by local gradual change.

Troy Dominguez (Philadelphia) reviewed the risk factors for nosocomial infections, with an emphasis on central line associated blood stream infection, ventilator associated pneumonia, surgical site infections, the particular vulnerability of patients with congenital cardiac disease given their high number of risk factors, and the crucial role of adopting a team approach for better control and prevention.

Richard Ohye (Ann Arbor), in an effort towards "Ensuring patient safety during clinical trials, the ethics of human subjects' research," gave surely the most humorous presentation of the session. The information given, though, was absolutely critical and gave the audience plenty to sink its teeth into. Dr. Ohye dared us to ask "Do trials help patients

and are they relevant?" He reviewed definition of various clinical trials, problems with historically controlled trials, the benefits of randomization, and the clever way in which, given the inexorable progress in medicine, trials using historical controls always tend to favor the current intervention at question. Dr. Ohye implored us to base our practice of medicine in research and to promote, as well with its attendant requirements for respect for persons, beneficence, justice, and equipoise. John Charpie (Ann Arbor) followed with a presentation on "Developing and maintaining an effective quality assurance and improvement program." We learned the multiple aspects of quality (safe, effective, patient-centered, timely, etc.) and the details and rationale behind the "Plan-Do-Check-Act" cycle for improvement.

Patricia Hickey (Boston) riveted us with her bold opening that mandated nurse staffing ratios are simply not the answer as they can exacerbate staffing- and work-related stress for staff nurses. Her presentation, "Rational work-hour assignments for bedside nurses: what's the rationale?" described that best practice in addressing nurse staffing depends on a multifactorial approach. The best models allow staffing to patient demand without having a negative impact on staff; nurses should maintain control and choice over their own schedules. Introduced to Florence Nightingale's edict to "put patient in best condition for nature to act," the audience was then led through Ms. Hickey's team's "Nightingale metrics" and her novel "continuity of care index."

The session closed with a terrific debate between Martin Elliott (London) and Alan Friedman on the pros and cons of restricted work hours for physicians. To most accounts, despite excellent arguments by both combatants, the contest was a draw (perhaps because all of the junior doctors had reached their work quota and were at the pool!). Nonetheless, patient safety remains a crucial element in improving outcomes for our patients. Look forward to upcoming meetings from Children's Hospital, Boston ([www.childrenshospital.org/clinicalservices/Site457/](http://www.childrenshospital.org/clinicalservices/Site457/))

main page S457P15 sub-level119Flevel120.html) the Hospital for Sick Children at Great Ormond Street in London, and The Children's Hospital of Philadelphia ([www.chop.edu/cardiology2008](http://www.chop.edu/cardiology2008)) to promote cardiovascular patient safety.



The closing plenary session on Heterotaxy Syndrome/Isomerism was perhaps the most well attended Sunday morning session of the past 10 years. The session was dedicated to the work and in honor of Stella Van Praagh who was lauded by all of the speakers for her insight into complex congenital cardiac disease, her compassion, her love of teaching her patients and her family. Professors Anderson and Weinberg concisely reviewed a very complex topic where nomenclature is perhaps the most controversial. For those of us (like myself) who were taught and 'grew up' thinking of these diseases as "polysplenia" and "asplenia," Professor Anderson made a very convincing argument to stick to nomenclature based upon the anatomy of the atrial appendages. Paul Weinberg compared Heterotaxy syndrome to "Murphy's Law:" if something can go wrong, it will! Peter Gruber

(Philadelphia) showed some new and exciting information regarding the genetic basis of abnormalities of sidedness being a 'proximal' event in cardiogenesis, with absolutely fascinating microscopic images of cilia directing cardiac cells to one side or another. Leo Lopez (Miami) reviewed the anomalies as shown by echo, Jack Rome (Philadelphia) did the same with angiography, and Mitchell Cohen (Phoenix) showed some very elegant examples of the abnormalities of the conduction system. The session closed with newly released data from the Pediatric Heart Network presented by Andy Atz (Charleston) from the recently completed Fontan cross-sectional study. Interestingly, despite having a higher complexity of disease (and most likely a higher initial mortality risk), the current survivors appear to be no different than other patients with a Fontan circulation in terms of exercise performance, laboratory assessments of ventricular function, and importantly, patient and parent reported quality of life.



The featured lectures this year were given by Martha Curley (Philadelphia), Philipp Bonhoeffer (London), Pedro del Nido (Boston) and Gavin Kerr (Philadelphia). Dr. Curley gave an inspiring overview of what it takes to be a mentor, what (and how) we learn from them, and how they start a generational process of learning, teaching and com-

passion. Dr. Bonhoeffer reviewed percutaneous pulmonary valve therapy from its humble beginning in the cow fields of France (collaborating with butchers), through stent design (collaborating with jewelers) through implementation in patients (collaborating with industry). His internationally known work was interspersed with funny anecdotes, and wonderful photos from his work in Africa. Dr. del Nido reviewed the pioneering work being done in Boston to 'recruit' two ventricles in the subgroup of patients with Hypoplastic Left Heart Syndrome and aortic and mitral stenosis.



His presentation covered surgical technique, fetal intervention and the underpinnings of basic science suggesting abnormalities of cell migration being the common denominator of such diverse diseases as pulmonary vein stenosis, mitral valve pathology and endocardial fibroelastosis. Finally, Gavin Kerr gave the first Keynote Lecture in Cardiovascular Administration, highlighting the partnership necessary between front-line care givers and hospital administration.

### Breakout Sessions

Echocardiography breakout sessions were well attended throughout the meeting, including overviews of three dimensional imaging (Girish Shirali, Charleston), fetal imaging (Jack Rychik, Philadelphia) and intracardiac imaging (Mike Brook, San Francisco). Difficult cases were reviewed by the

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faculty in an informal session, and Leo Lopez, Michele Frommelt and Norman Silverman (San Francisco) gave wonderful overviews of specific cardiac lesions.

Similarly, the inpatient breakout sessions for intraoperative care, surgery, perfusion and intensive care were comprehensive and insightful. New strategies in monitoring using near infrared spectroscopy are becoming more ubiquitous in our field, and front line experts from Houston, Milwaukee and Charleston updated the group on current strategies and results. A particular focus of all of the breakout sessions was on reducing morbidity, particularly to the central nervous system. Dean Andropoulos and Chuck Frasier (Houston) presented their current "best-practice" model to intraoperative perfusion and monitoring, followed by informal comments from practitioners in Philadelphia, Boston, Ann Arbor and Milwaukee. Lara Shekerdemian (Melbourne) then updated the audience on their prospective studies following neonatal surgery in Australia. Andrew Redington once again showed some seminal work being done on remote ischemic preconditioning, perhaps one of the best examples of translational research we have seen in our field.



monary hypertension, routine screening for cardiovascular disease, heart transplantation, Barth's Syndrome, Marfan Syndrome, exercise testing and outpatient decision analysis, to name just a few. Smaller subspecialty breakouts were also held in developmental cardiology, electrophysiology, interventional catheterization and cardiovascular administration.

Nursing has traditionally been a particularly strong component of this meeting, especially in terms of the science presented by the faculty and the number of attendees from all disciplines in nursing. This year was no exception with a featured nursing plenary session, a hands-on research planning session and nearly 20 abstracts submitted by nurses from

around the globe. Barbara Medoff-Cooper (Philadelphia) and Mary Fran Hazinski moderated the first nursing plenary session which focused on the care of neonates with hypoplastic left heart syndrome Eliot May (Milwaukee) led a thorough discussion of low cardiac output in the early postoperative period and the usefulness of continuous monitoring of mixed venous oxygen saturation and near infrared spectroscopy in early detection and early intervention. Erika Wintering (Phoenix) followed with an excellent review of preoperative and postoperative ventilation strategies, using examples and research to highlight key points. The remainder of the session addressed long term morbidities. Barbara Medoff-Cooper presented late



The outpatient cardiology breakout sessions were also comprehensive and well attended, including topics such as pul-



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***“From over 100 initially submitted, 65 abstracts were presented in two separate poster sessions from 40 institutions and 16 countries.”***

breaking results from her National Institutes of Health funded study of feeding patterns in newborns with congenital cardiac disease, and focused on some of the concerning results in this population - reduced length, weight, and head circumference at 3 and 6 months of age. Jo Ann Nieves (Miami) reviewed her international survey results on practice variability, and Nancy Rudd (Milwaukee) reviewed the results of their formalized home-monitoring program, which has resulted in a dramatic reduction of inter-stage mortality at that center. Kathy Mussatto (Milwaukee) closed the session with an insightful look at factors affecting quality of life for our patients and their families.

The second nursing plenary session focused on low cardiac output syndrome. Jo Ann Nieves and Erika Wintering reviewed several strategies for recognition and management of low cardiac output, which was followed by a comprehensive review of mechanical support of the failing circulation by Lisa Moore (St. Petersburg). A special sunrise session was held with Barbara Medoff-Cooper and Kathy Mussatto on how to get nursing research off the ground, funded and published, followed by presentation of the top three nursing abstracts.

For the first time at this meeting, a full half-day session was devoted to Career Planning for Trainees and Junior Faculty, including rarely-discussed topics at

scientific meetings such as: job interview skills, negotiating salary and benefits, comparisons of academic and private practice, work-life balance, managing funding and choosing an academic career and mentor. They graded very favorably by the trainees and junior faculty alike, and will most likely become a routine part of future meetings. An opening plenary session featured a wonderful talk on why clinical pediatric cardiology practitioners need to know about basic science from Jon Epstein (Philadelphia), a self-flagellating talk by Martin Elliott on what he endured during his surgical training, and commentary by yours truly on how the theory of cognitive dissonance in social psychology pertains to the way we read (and sometimes dismiss) the literature and respond to new and/or conflicting data.

Two pre-conferences were also held one on cardiac anatomy and imaging and one on resuscitation. The anatomy/imaging pre-conference was attended by nearly 150 physicians, nurses and sonographers, and featured anatomic specimens from the Cardiac Registry in Philadelphia and the Van Mierop collection in Gainesville. Wonderful correlations between the specimens and imaging examples brought it all together for the attendees.

The simultaneous session on ‘mock codes’ was coordinated by Stacie Peddy (Philadelphia) the team from the Center for Simulation, Advanced Education and Innovation at The Children’s Hospital of Philadelphia. Small group didactics were held, but most of the experience was ‘hands-on’ with real life cardiac intensive care scenarios and the use of the SimBaby from Laerdal. Working in small groups, the participants were taken through both predictable (low cardiac output, tachyarrhythmias) and sudden, unanticipated events (respiratory failure, cardiac tamponade and shunt thrombosis) that characterize the 24-48 hours

after cardiopulmonary bypass. In addition, pre-operative scenarios (hypercyanotic spell in the patient with unrepaired tetralogy of Fallot) and medical scenarios (acute fulminant myocarditis) were utilized as well. Each SimBaby station was staffed with clinical and simulation facilitators and teams of 3-4 participants “rotated” through all 7 scenarios. Through open communication and role assignment each team actively worked through the clinical scenario presented to them. The learning objectives were reviewed and an inclusive debriefing session was given at the completion of each scenario.

The scientific sessions were rounded out by sunrise hands-on sessions on near infrared spectroscopy, cardiopulmonary bypass, automatic external defibrillators and permanent pacing.

#### **New Learning Technology and Social Events**

No conference would be complete without a bit of fun and games. The weather could not have been better for the 3rd annual pre-conference golf tournament at the beautiful Lake Buena Vista golf course, one of Disney’s finest. Twenty golfers of diverse talents journeyed from the farthest reaches of the earth (such as London, Michigan and Wisconsin) to gather for their early morning tee times. Jim Tweddell, Mitch Cohen, Christine Anderson and Paul Stephens had 5 birdies and a single bogey for the winning score of 4 under, one a shot ahead of Jon Fleenor, Mike Mulreany, Scott Maurer and Bert Ross. Scott Maurer hit the longest drive on the par 4 ninth, which plays 360 yards. His tee shot landed only 30 yards from the green, so if my math serves me right, that is 330 yards of muscle and accuracy. Please plan on attending the 4th annual tournament next year in Scottsdale.



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An audience response system was used for the first time to document anonymous audience responses to various clinical scenarios. In the physician session, a number of cases were shown similar to most center's 'surgical conference', once again highlighting areas that require further investigation, such as optimal management strategies for common disease (for example, small ventricular septal defect with aortic regurgitation, management of atrial septal defect) and consensus guidelines for outpatient follow-up. In the afternoon session, nearly 500 respondents were led by Geoff Bird (Philadelphia) in a series of clinical scenarios which highlighted the incredible diversity of management styles around the globe, including management of hyperglycemia (as many respondents used insulin protocols as those who offered no treatment), types of inotropic support and the routine use of delayed sternal closure.

Mike Brook starred as Alex Trebek in Cardiology Jeopardy, simulating the popular game show. Three teams competed on topics from geography, radiographs, boils and sores and historical facts. The 'home' team from The Children's Hospital of Philadelphia (Tom Spray, Jack Rychik and Gil Wernovsky) was pitted against a United States team (Norm Silverman, Tim Feltes and Jim Tweddell), and an All-World team (Andrew Redington, Martin Elliott and Dan Penny). Despite cries of 'foul' and controversial answers, the United States team won in a close battle. Jeopardy is sure to become a standard offering in future meetings.

Finally, there were a number of networking receptions for nurses, trainees, staff physicians and perfusionists, and the Gala Reception was followed by the 1st annual Cardiology Ensemble, featuring musical numbers from the faculty and attendees.

**Future Directions**

Cardiology 2008 is planned for February 6-10, 2008 in Scottsdale, Arizona. Highlights from this meeting, as well as those from the 7th Annual International Symposium on Congenital Heart Disease (St. Petersburg, Florida) will be published as a supplement to Cardiology in the Young in the Fall of 2007.



Special thanks to the Staff of the Cardiac Center for their contributions to this report.

~CCT~



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## MEDICAL NEWS, NEW PRODUCTS AND INFORMATION

### New Digital Grid Will Link Heart Researchers Worldwide: A US Federally Funded Project Will Allow International Access to Cardiovascular Medical Data

Supported by an \$8.5 million federal grant, leading researchers at three universities, including Johns Hopkins, are creating an ambitious digital network that will allow cardiovascular researchers worldwide to easily exchange data and expertise on heart-related illnesses. The project, called the Cardiovascular Research Grid, is expected to be a boon to the large community of heart researchers who will use these digital tools to find new ways to prevent, detect and treat life-threatening cardiac ailments. To launch this effort, the National Heart, Lung and Blood Institute, part of the National Institutes of Health, has approved an \$8.5 million grant to be allocated over a four-year period that began March 1, 2007.

The digital project will be based at the Institute for Computational Medicine at Johns Hopkins, in collaboration with the Department of Biomedical Informatics at Ohio State University College of Medicine and the Center for Research in Biological Systems, University of California, San Diego. The project teams will develop open, grid-based software tools that will enable other research groups to become a "node" in the new grid. Once connected to the grid, researchers will be able to access and share experimental data, data analysis tools and computational models relating to heart function in health people and those with cardiac disease. To protect privacy, none of the heart data will carry information identifying patients from whom it was obtained. "There had never been a simple and direct way for cardiovascular researchers to share, analyze and model this important data," said Raimond Winslow, director of the Institute for Computational Medicine at Johns Hopkins and principal investigator in the project. "Now, there will be." Winslow, who also is a professor in the Department of Biomedical Engineering, added, "This is the direction in which biomedical research is heading in the 21st Century. In the past, biomedical research was mainly done in individual labs. The Cardiovascular Research Grid will enable us to assemble large, geographically distributed research teams and bring together the leading experts in the world to focus on a common problem, regardless of their location. This



Raimond Winslow  
Photo by Will Kirk

grid will enable experimentalists to share their data with computational scientists, who will analyze and model the data. The computational scientists will then share their results with their experimental colleagues who use it to refine their experiments. In this fashion, we believe the creation of the Cardiovascular Research Grid will accelerate the discovery of new approaches for treating heart disease."

In deciding to fund the new grid, the National Heart, Lung and Blood Institute recognized the important contribution that bioinformatics can now make in developing a deeper understanding of the mechanisms of heart disease and in the development of new therapeutic approaches. During the first year of funding, the organizers of the new grid plan will deploy the initial infrastructure and software that will enable researchers to begin sharing and analyzing information. To accomplish this, Joel Saltz, chair of the Department of Biomedical Informatics and the Davis Endowed Chair of Cancer at Ohio State University, and his team will develop the software infrastructure that ties together resources on the grid. "The Cardiovascular Research Grid will allow experts from different disciplines to combine their insights and to coordinate their efforts," Saltz said. "The ability to bring together many types of biomedical information will have a tremendous impact on the pace of progress in cardiovascular research"

The Johns Hopkins team will focus on development of standardized vocabularies for describing biomedical data, models and data analysis applications. In addition to Winslow, the team will include faculty members Michael I. Miller and Tilak Ratnanather from the Department of Biomedical Engineering; and Donald Geman, Daniel Naiman and Laurent Younes, all from the Department of Applied Mathematics and Statistics. Mark Ellisman, director of the National Center for Microscopy and Imaging at the University



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of California, San Diego, and his team will be responsible for developing effective and intuitive ways for users to interact with the Cardiovascular Research Grid. "Developing and deploying cyberinfrastructure to capitalize on emerging technologies to promote better collaboration and accelerate research is a core focus of our Center's efforts," said Ellisman, who also is director of UCSD's Center for Research in Biological Systems. "With a track record of developing scalable cyberinfrastructure to foster interdisciplinary investigations among teams of researchers in microscopy, neuroimaging and the environmental health sciences, CRBS is eager to collaborate with the John Hopkins team on developing the Cardiovascular Research Grid. We're looking forward to implementing an infrastructure that will effectively pool the diverse expertise, applications and instrumentation of the cardiovascular research community into a unified knowledge base—one that will enable researchers to tackle cardiac disease studies of greater scope and complexity."

The Cardiovascular Research Grid will be headquartered in the 79,000 sq. ft. Computational Science and Engineering Building, now under construction on the Homewood campus of Johns Hopkins. The building is expected to open this summer.

**Related Links:**

Institute for Computational Medicine at Johns Hopkins: [www.icm.jhu.edu/](http://www.icm.jhu.edu/)

Johns Hopkins Department of Biomedical Engineering: [www.bme.jhu.edu](http://www.bme.jhu.edu)

National Heart, Lung and Blood Institute: [www.nhlbi.nih.gov](http://www.nhlbi.nih.gov)

**SickKids Opens the Mitchell Goldhar Cardiac Diagnostic & Interventional Unit, a State-of-the-Art Cardiac Diagnostic and Interventional Unit Specially Designed for Children**

The Mitchell Goldhar Cardiac Diagnostic & Interventional Unit at The Hospital for Sick Children (SickKids) was opened on April 30, 2007. This new unit will enable Canada's largest paediatric interventional catheterization program to develop new innovations in minimally invasive alternatives to open-heart surgery.

The newly integrated unit combines the latest technology to diagnose and treat children with congenital heart disease using minimally invasive procedures that can reduce or eliminate the need for open-heart surgery. The 18,000 sq. ft. unit includes two new catheterization labs with state-of-the-art equipment, an integrated magnetic resonance imaging (MRI) machine and a post-anaesthetic recovery area for patients. Designed with children in mind, the unit's outer space theme provides a fun and stress-free environment in waiting areas, corridors and treatment rooms. Built-in lava lamps, an interactive "asteroid," as well as colorful lights and wall decorations are designed to distract patients from upcoming procedures.

"The new unit allows us to explore new minimally invasive treatments that put less strain on children with cardiac conditions," says Dr. Lee Benson, director of The Mitchell Goldhar Cardiac Diagnostic & Interventional Unit. "Ultimately, we want to improve the quality of care and life for children with heart disease and The Mitchell Goldhar Cardiac Diagnostic & International Unit will help us achieve our goal."

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June 27-29, 2007

The establishment of The Mitchell Goldhar Cardiac Diagnostic & Interventional Unit was made possible with \$23 million in combined funding from the Ministry of Health and Long-Term Care and from a committed group of donors to SickKids Foundation. The Ministry of Health and Long-Term Care provided \$7.2 million to fund the unit.

“Toronto is proud to be home of one of the world’s leading care, research and teaching hospitals focused on child health,” said George Smitherman, Minister of Health and Long-Term Care. “The Mitchell Goldhar Cardiac Diagnostic & Interventional Unit will allow SickKids to continue to be on the leading edge of technology and care for the benefit of children across the province and the families who care so dearly for them.”

The unit also received funding from private donors totaling \$15.8 million. A gift of \$3 million from Mitchell Goldhar, owner and CEO of SmartCentres, completed the private funding commitment to the unit. Other major donors to the unit with gifts of more than \$1 million or more included: Gary Slaight and Standard Broadcasting Corporation and their listeners, Ruth and Douglas Grant, David and Judy Galloway, Jennifer Ivey Bannock and the Richard Ivey Foundation.

“People don’t associate heart disease with young children,” said Mitchell Goldhar, owner and CEO of SmartCentres. “But children of all ages do have heart problems, some from the time they are born. It was important for me to invest in an area that I knew would have lasting impact. As far as I am concerned, SickKids is the best place in the world to improve a child’s outcome for a better quality of life and a healthier future.”

Every detail in the unit has been designed to provide a distracting and entertaining environment for children. The entrance to the unit sets the stage for a child’s journey through outer space. Patients will first encounter a large “asteroid” that symbolizes a real meteorite that landed on earth over 5,800 years ago. Funded by the Women’s Auxiliary of The Hospital for Sick Children, the asteroid has many hidden features and stories that children will want to explore on each visit to the unit. The patient reception area also features a virtual interactive game, computer kiosks and a wall of lava lamps that will entertain both children and their families.

The Labatt Family Heart Centre at SickKids is already home to the largest paediatric interventional catheterization program in Canada and continues to be a leader in Ontario

for innovative procedures to treat complex cardiac conditions in children. It conducts approximately 90 per cent of cardiac catheterization procedures for Ontario children, with 1,000 catheterizations performed last year. Approximately half of these procedures are interventional, while the remaining half include diagnostic, electrophysiological, ablation and pacemaker-related procedures.

SickKids Foundation was established in 1972 and is celebrating its 35-year anniversary. Its mission is to inspire our communities to invest in health and scientific advances to improve the lives of children and their families in Canada and around the world. Its vision: Healthier children. A better world. The Foundation is the largest non-governmental granting agency in the area of child health in Canada.

The Hospital for Sick Children (SickKids), affiliated with the University of Toronto, is Canada’s most research-intensive hospital and the largest centre dedicated to improving children’s health in the country. As innovators in child health, SickKids improves the health of children by integrating care, research and teaching. Our mission is to provide the best in complex and specialized care by creating scientific and clinical advancements, sharing our knowledge and expertise and championing the development of an accessible, comprehensive and sustainable child health system.

For more information, visit [www.sickkids.ca](http://www.sickkids.ca).

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