



The Academy NEWSLETTER

THE AMERICAN ACADEMY
OF
CARDIOVASCULAR PERFUSION
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SPRING 2011

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32nd Annual Seminar of The American Academy of Cardiovascular Perfusion Grand Sierra Resort and Casino Reno, Nevada January 27-30, 2011



The 2011 AACP National Meeting: The Student Perspective

Ashleigh Trew
SUNY Upstate Class of 2011

As a perfusion student, it was initially intimidating to think of attending and presenting at the American Academy of Cardiovascular Perfusion meeting. I was very enthusiastic but nervous to attend thinking of all the possibilities; job prospects, meeting perfusion 'legends', presenting in front of so many veteran perfusionists. On the first day of the meeting my worries were eased when I realized that it was not only about the perfusionists, but the students as well. The students were made to feel very supported and welcomed and not outcasts as I imagined. "The Academy members were extremely approachable and engaging and made me feel welcomed into this field", said Trevor Smith SUNY Upstate student. "Perfusion is a strong, small commu-

nity of which I was made to feel very welcome", said Nicole Tomasello SUNY Upstate student. Several perfusionists expressed how the recruitment of students is key for the future of perfusion organizations which made me feel appreciated and a part of the profession.

Not only did we have the opportunity to network with several perfusionists throughout the country, but meeting other perfusion students was comforting and encouraging. There was even a students' only fireside chat where we were able to discuss resumes, job interviews, our experiences and more. Academy members also put together a meet and greet for students after the fireside chat where we had time to mingle with the members in a lower vol-



Left to Right: Sarah Lombardi, Adam Yamin, Nancy Sponable, Jessica Bui, Robert Brown, Krystal Gleeson, Jessica Crane, Nicole Tomasello, Kayla Thomas, Ashleigh Trew, Jenna Cornibe, Trevor Smith, Edward Laine, Jacoby Jose, Dafne Chianella

ume setting. "I was really impressed with the amount of time and effort most people took to speak with us outside of the scheduled talks such as lunches, wine reception, as well as get our opinion on issues during the Fireside Chats", said Nancy Sponable SUNY Upstate student.

Presenting was nerve-racking but left me with a sense of accomplishment and purpose. After the presentations, there were several people who commended the student presenters for have the courage to get up there and present to a room full of knowledgeable perfusionists. "Networking with the experienced perfusionist was effortless and rewarding", said Adam Yamin SUNY Upstate student. Not only were we supported by attendees but The Woods Insurance group generously contributed funds to each perfusion student in attendance which greatly eased the financial burden. I believe it is crucial for perfusion students to participate not only in the operating room, but contribute and show support to the professional organizations as well. "I feel that attending the AACP meeting will open students eyes even more to how truly amazing and unique the perfusion profession is!", said Jenna Cornibe, UPMC Presbyterian student. By combining the expertise of veteran members with the drive and innovation of younger members will create a future of success and longevity of the Academy. I would highly recommend future students to attend the meetings and know that they will be well received.

Hello Members of the AACP!

I have now been home from the 2011 Annual Seminar for two days. Although I am back in the operating room pumping several cases each day, my luggage remains right inside the door of my condo with the contents untouched. I know I am not the only one and there are many others of you out there!

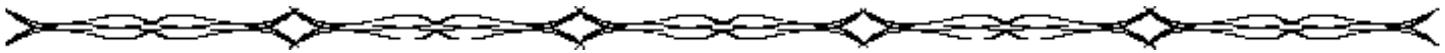
Currently, I am a full-time student in the perfusion program at the University of Pittsburgh Medical Center. Under direct supervision of staff perfusionists, I am able to experience practically everything the profession has to offer on my rotations throughout the health system. This stems from your everyday CABG's to organ transplants, aortic dissections, chemoperfusions, and ventricular assist devices.

Although the clinical understanding that I will receive in my education will eventually lead me to the hopeful end product of a CCP, the priceless experience that occurred in Reno last week is a forever testament as to why I chose this profession.

As I sat in the Reno Ballroom of the Grand Sierra Resort and Casino, I could not help but look around at the countless pioneers of perfusion. The expertise and years of dedication could not possibly be quantitated. Listening to fascinating presentations exhibited by both students and members alike was mind blowing in itself. Whether it is being clinically educated by a simulator instead of a patient, or using a one-time dose of Del Nido cardioplegia versus microplegia, the principle still remains. Our goals as perfusionists are the same and I was quick to realize just how many different ways there are of achieving them. I was shown a warm welcome from members of the academy who resided all over the United States, even the "cheese heads" from Wisconsin. Spending time with other students from several different programs in our "students only" fireside chat on Saturday afternoon has sparked friendships that will undoubtedly last a lifetime. It will be thrilling to see where our career paths take us within the next year.

In close, I want to thank all of you for the impact you have made on me. Whether it was the quick chat over coffee in between sessions, the conversation about your life as a perfusionist at the sponsors' reception, or the simple hello in passing; you made an impression on me that will last a lifetime. A special thank you also to the council for adding the student wine and cheese reception to the agenda and to David Wood of the Wood Insurance Group for the generous donation which helped to defray the expenses of all the students. The future of perfusion is as bright as ever and I could not be more proud to be a part of it. I can only aspire to one day sit amongst your ranks with the incredible expertise that you all possess. I can assure you that my undying passion for the perfusion profession will keep the fire burning, just as Ed Darling's motivational lecture encouraged. Until we all meet again in New Orleans, best wishes and God Bless!

Sincerely,
Jenna L. Cornibe



Welcome to New Members

The American Academy of Cardiovascular Perfusion would like to welcome the following individuals whom were voted into membership at the Closing Business Meeting of our annual

Fellow Membership (formerly Active)

Kevin Griffith
Thomas Preston
John St.Onge

Jenna Cornibe
Jessica Crane
Jamisa Curry
Nathan Darrow
Debarshi Datta
Richard Denison
Laura DiCocco
Diane Gansert
Krysta Gleeson
Margaret Harrington
Shannon Heard
Laura Hook
Tyler Kelting
Edward Laine
Greg MacLean
Amy Malcolm
Caitlin Morda
Vivan Nguyen
Molly Oldeen
Paola Revuelta
Tiffany Robb
Stephen Robinson
Julianne Southwell
Nancy Sponable
Emily Stockard
Kayla Thomas
Stephen Thomas
Scott Thompson

Member Membership (formerly Associate)

Jennifer Barnum
Michael Brigham
David Carlson
Giovanni Cecere
Kirk Dunst
Hasratt Mohamed
Dayna Murphy
Jeegna Patel
Thomas Rath
Akilah Richards
Jordan Voss
Andy Ward

Student Membership

Meyyappan Arunachalam
Javed Asuani
Danielle Berkovitz
Katie Bertrand
Brady Blazek
Josh Blessing
Loveleen Chana
Hsiang Chiao

AACP 2011 Officers and Council

President

Daniel FitzGerald
Winchester, MA

Treasurer

Steven Raskin
Richmond, TX

Mindy Blackwell
Charleston, SC

Vice-President

Linda Mongero
Locust Valley, NY

Council Members

Edward Darling
Past President
Baldwinsville, NY

William Harris
Luling, LA

Karen Jones
Churchville, NY

Secretary

Vince Olshove
Columbus, OH

D. Scott Lawson
Aurora, CO

The Student Section

Mechanical Circulatory Assist Devices as a Bridge to Destination Therapy and the Ethical Implications

Over five million people in the United States are in heart failure.¹⁻³ While it is widely agreed upon that a heart transplant is the best way to treat end-stage chronic heart failure, it is impractical to rely on this management for all cases.⁴ An estimated 100,000 of these patients can meet recipient criteria, but under 2,200 hearts are available each year for donation and this number is decreasing.^{1,2} To fill this gap there has been development of mechanical circulatory assist devices which are used in patients recovering from a cardiac procedure, waiting for a heart transplant or will be dependent upon the device for the remainder of their lives. Destination therapy applies to patients that have contraindications to transplantation such as age greater than 65, chronic renal failure, or type I diabetes with organ failure.⁵ According to the Centers for Medicare and Medicaid Services, patients receiving a destination therapy mechanical assist device must be in Class IV heart failure and have shown no improvement with pharmacological management, have a left ventricular ejection fraction less than 25%, have an appropriate body size that allows implantation and have a functional limit of peak oxygen consumption of less than 12 mL/kg/min.⁶ While the field of mechanical circulatory devices continues to advance, it is important to step back and consider the ethical considerations involving the patient, patient's family and the entire healthcare team.

There are several risks associated with the implantation and use of a mechanical circulatory device including surgical mortality, failure of the right heart, thrombus formation, neurological events, device malfunction and infection.⁵ While most of these risks are associated with any cardiac procedure the most common with the implantation of an assist device is the risk of infection and sepsis. It is estimated that 18-59% of patients develop an infection with highest likelihood about 3 weeks after implantation.^{3,7} This number is variable as

there is no standardized method to categorize and report device-related infections.⁷ Infection can originate at the surgical site, the driveline, the pocket that holds the device or within the pump itself.^{5,7} In the REMATCH study, the incidence of sepsis was double for the group receiving a left ventricular assist device compared to the medical-therapy group and also significantly higher for local infections.⁸ Another risk that is only attributable to the use of an implantable device is the possibility for device failure. Any device malfunction that decreases the ability to adequately support the patient's circulatory needs is life threatening.⁹ Within the first two years of the REMATCH trial, 35% of the HeartMate left ventricular assist devices experienced system failure.⁸ Malfunction is most likely to occur with wear on the bearings, failure of the motor and breaks in the lining.^{5,8} These risks must be considered with multiple consent forms before advancing toward implantation of an assist device.

Complete informed consent is a concept that has been questioned in health care.⁹ Can a patient truly have total comprehension of the disease process and treatments? While this seems like a simple enough conversation, there are many facets of heart disease and the body's physiological response to these changes that have taken years for scholars to grasp. After understanding the course of heart failure, the next task is to comprehend the proposed procedures along with all their risks and benefits as well as any alternative therapy available.⁹ Despite a patient being willing to learn about the options, there is often not enough time or framework of knowledge in order for complete informed consent to be attained. While the freedom to make medical decisions should be given to the patient in order for them to retain autonomy, there is question if the information can be fully presented without

Michelle Benson

Midwestern University
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Glendale, Arizona



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bias. Even with just these first two obstacles of informed consent considered, an ethical dilemma starts to form.

While it is not ideal to implant a device until the patient is fully aware of risks, benefits, amount of expected visits to hospital, and possible financial burden, in an emergency situation options are limited. The term is 'bridge to compliance,' where the device is implanted to prolong the patient's life until a thorough care plan is generated which may or may not continue the use of the assist device.¹⁰ A lack of compliance encompasses a patient's inability to follow up with healthcare providers, comply with medication regimens, maintain cleanliness to avoid infection, or making lifestyle changes such as smoking cessation.¹⁰ Knowledge and ability to perform maintenance and troubleshooting of the device is vital in order to discharge the patient.¹¹ Unless an around-the-clock caregiver can be guaranteed, the patient must have the capacity to execute these functions. Within these specifications, contraindications would include mental retardation, or irreversible cognitive declines such as dementia.^{10,11} A patient suffering with an addiction would be considered a contraindication for implantation. When can and should a line be drawn for denial of destination therapy? This begins to enter situations where one healthcare provider's recommendation could deny a patient treatment.

The burden of someone becoming a primary caregiver is another consideration to take into account when considering implantation. While most destination therapy devices are implanted in an older population with an equally aging spouse, the amount of additional family support or other community involvement could aid in a successful long-term outcome.⁵ Caregivers are entrusted with the responsibility of troubleshooting and making frequent and unplanned visits to the hospital.⁹ High amounts of stress, anxiety and depression on the primary caregiver can cause the health of the caregiver to decline. Often a hired caregiver can alleviate some stress, but this is not an option for families already struggling with the financial burden of the device. Still, a patient could be faced with returning home where there is no primary caregiver. Does a lack of social support mean a patient does not qualify for implantation? With all of these possible contraindications for the implantation of an assist device, the ethical decision comes when deciding if implantation will be beneficial. If the patient is unable to properly respond to an alarm or lacks psychosocial support, should a device implantation be withheld?

While mechanical assist devices were developed in order to extend a patient's life, there should be an in-depth discussion between healthcare professionals, the patient and the patient's family about what quality of life means. Quality of life involves many aspects including physical, spiritual, financial, and social well being.⁹ Suc-

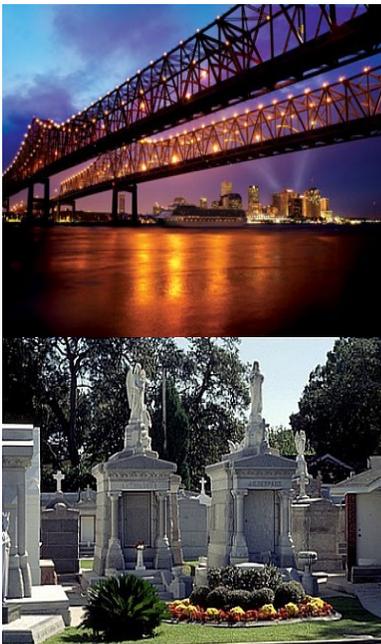
cessful placing and activation of a device should improve the physical quality of life for the patient. In the REMATCH trials, 15 out of 23 of the patients with a left ventricular assist device reported not being physically limited when climbing a flight of stairs, where all of the pharmacologically treated patients reported some limitation.⁸ However, with implantation other quality of life indicators could decline. Patients should expect regular doctor visits as well as emergency rooms and extended hospital stays that accompany device malfunction, infections or complications from comorbidities. The bottom line is that implantation can become a financial burden on a family. In the initial REMATCH trial, the implantation procedure and hospital stay alone cost more than \$200,000.⁷ Another aspect less considered with a decline in quality of life is a lack of social support. A patient could be required to move from a rural community to a city in order to continue care from a larger hospital that supports assist devices.⁹ Patients must also be comfortable with the fact that they will be attached to a machine, which may present additional mobility impairments, changes in daily living, as well as risk of infection and neurological events. It is a very personal decision for a patient to make regarding standards of life and there are numerous questions health professionals can ask to measure the patient's perception of quality of life.⁹

While there are truly no solutions to ethical dilemmas, there have been suggested routes to take in order to provide the patient with the best outcomes. This includes involving all members of the interdisciplinary team as well as the patient's family, community and spiritual guidance.⁹ Palliative care should be provided early on in the disease process and continued even with the implantation of a circulatory assist device.^{9,10} As many comorbidities are associated with the development of heart failure so are emotional and psychological symptoms such as depression, sleep disorders and anxiety.¹⁰ A comprehensive care plan should be laid out and agreed upon by the patient and caregivers in the event of device malfunctions, declines in quality of life and advanced planning of device deactivation resulting in progression to death.⁹ There are many ethical dilemmas within providing treatment to patients. Each care plan is prepared differently depending on the patient, family, religious background and even region of the country. Each individual situation cannot be addressed in a handbook or within guidelines, but must be assessed per patient and situation involving all members of the healthcare team. This should be done as a shared process where all involved parties must be willing to interact and spend time answering questions in order to make adequate decisions. While there are certainly contraindications and ethical dilemmas involved in the use of mechanical circulatory assist devices it is crucial to remember the positives and to weigh each when determining a care plan for each patient.

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2012 Annual Seminar



Omni Royal Orleans Hotel
New Orleans, Louisiana
 (Located in the French Quarter)

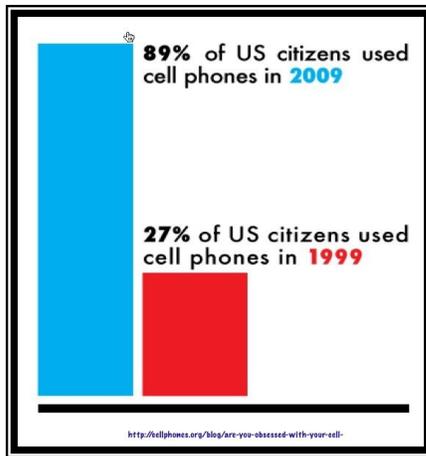
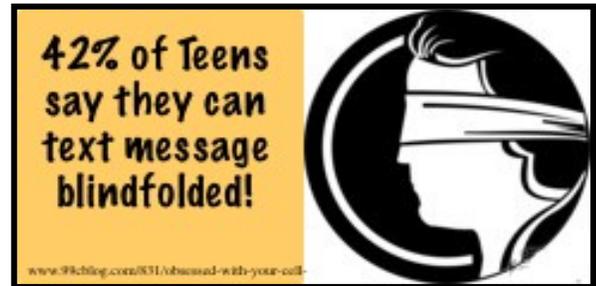


January 26-29, 2012

ON BYPASS

Cell Phone and CPB: Dangerous Distraction or the New Normal

We are in the midst of a communication revolution. Cell phones and smart phones are changing the way we live and work. The use of cell phones by US citizens has increased from was 27% in 1999 to over 89% in 2009. Within all demographics, cell phones are becoming firmly embedded into our culture.



The adoption of mobile devices has been so rapid over the last decade that most students entering perfusion school have never known a life without the convenience of instant communication.

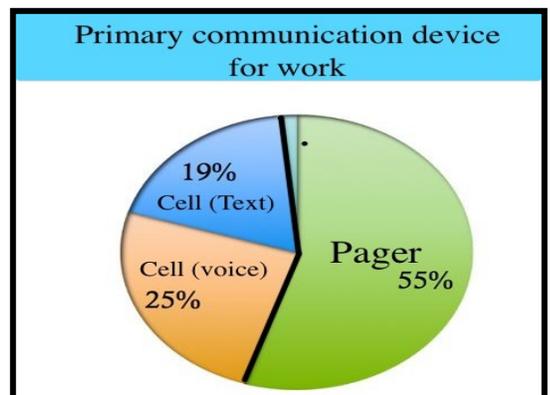
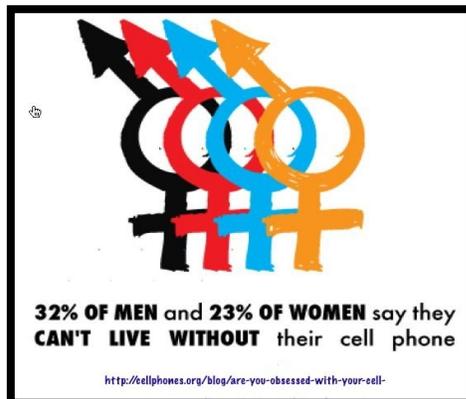
What about cell phone use by perfusionists and while performing bypass? We set out to see what impact this communication revolution has had on the perfusion community. Therefore, in the fall 2010 four hundred thirty six (436) perfusionists were surveyed to (1) determine the frequency of cell phone use, and (2) to identify concerns and opinions among perfusionists regarding cell phone use. There were 439 respondents. Demographic distribution is as follows; Chief Perfusionist (30.5%), Staff Perfusionist (62.0%), and Other (7.5%) with age ranges of 20-30 years (14.2%), 30-40 years (26.5%), 40-50 years (26.7%), 50-60 years (26.7%), >60 years (5.9%). One hundred percent of the respondents owned a cell phone or smart phone and while the pager is still the dominant, cellular phones (either voice or text messaging) have been adopted by 44% of perfusionists as their primary work communication device.

In fact, thirty-two percent (32%) of men and 23% of women say that they *can't live* without their cell phone. With young adults, texting has replaced verbal phone conversations as the preferred mode. In this regard, the average teen will text over 3300 times each month and have become so proficient that 42% say they can text blindfolded!

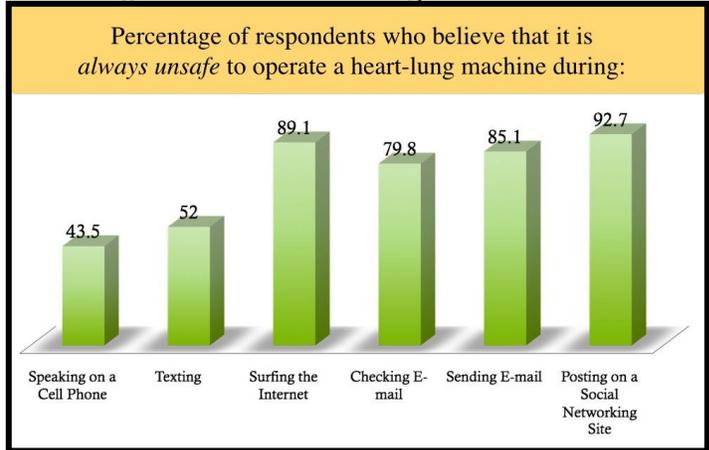
Trevor Smith, BS
Edward Darling, MS, CCP
Bruce Searles, BS, CCP

SUNY Upstate Medical University

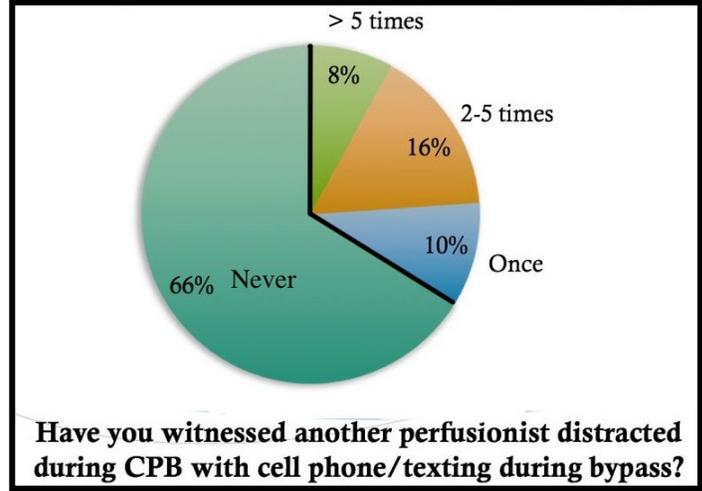
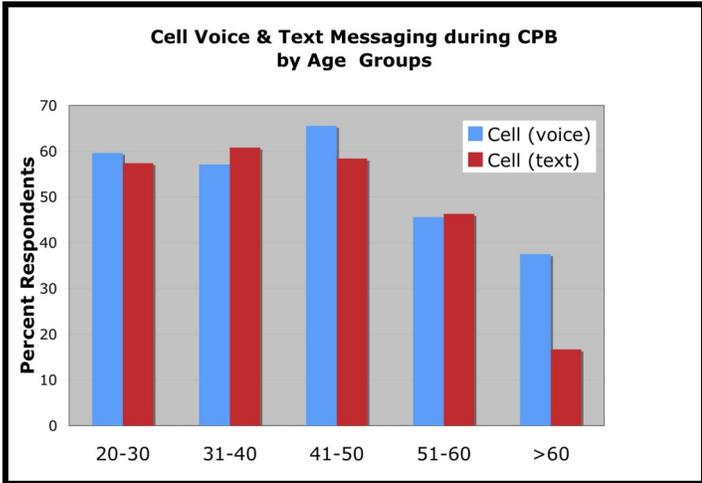
Syracuse, New York



The use of a cell phone during the performance of CPB was reported by 56% of perfusionists. Sending text messages while performing CPB, was acknowledged by 54.5% with clear generational differences detected when cross-referenced with age groups. For smart phone features, perfusionists report having accessed email (31.5%), using the internet (21%), or have checked/posted on social networking sites (4.5%) while performing CPB.

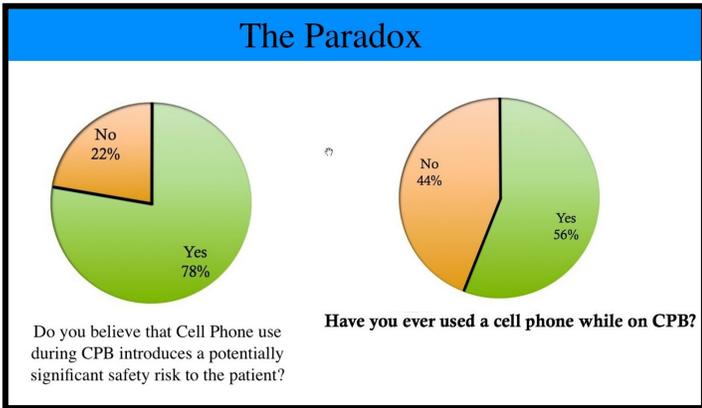


Speaking on a cell phone and text messaging during CPB is regarded as “always an unsafe practice” by 42.3% and 51.7% of respondents respectively. Personal distraction by cell phone use that negatively affected performance was admitted by 7.3%, whereas witnessing another perfusionist distracted with phone/text while on CPB was acknowledged by 33.7% of respondents. Currently, 36.5% of hospitals and 16.5% of perfusion departments have a policy regarding cell phone use.



This survey suggests that the majority of perfusionists believe cell phone raises significant safety issues while operating the heart lung machine, however, the majority also have used a cell phone while on pump. There are clear generational differences in opinions on the role and/or appropriateness of cell phones during bypass. One-third of perfusionists have witnessed another perfusionist distracted due to cell phone use while on CPB, with very few perfusion departments having cell phone policies. The potential for lawsuit in the event of a perfusion related accident with concurrent cell phone use is high. There is a need to further study this issue and, perhaps, to establish consensus on the use of various communication modes within the perfusion community.

A safety paradox was noted in the survey. While 78.3% of perfusionists believe that cell phones can introduce a potentially significant safety risk to patients, the majority of perfusionist have, in fact, used a cell phone during the performance of CPB.



The full manuscript of this article has been submitted to the journal *Perfusion* for possible publication.

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Choosing A Cerebral Oximeter, Is It Really A No-Brainer?

Cerebral oximetry is rapidly becoming the standard of care in many health care institutions. The accuracy of a device is paramount to patient outcomes, safety and care. When given the growing number of cerebral oximetry devices available, clinicians will need to make important decisions as to which device will best fit the needs and accuracy in their practice. Pertinent questions are critical in this decision process. Clinicians need to understand that each system is not equal in respect to technologies or their algorithmic processing. These inherent differences in technologies can and do impact the device accuracy, but also the utility and reliability in your clinical practice. So, what questions should clinicians ask? What do you need to know and understand? What test or evaluation should be conducted in the patient setting?

Here at St. Francis, Dr. George McCluskey performs around 800 shoulder repairs a year in the beach chair position and is one of the leaders in this field of orthopedic surgery. Two-thirds of arthroscopic and open shoulder procedures in the US are performed in this sitting position. Although the safety in this position has been well-documented, rare catastrophic neurological events have been reported. Evidence-based literature highly recommends the use of cerebral oximetry during and before this procedure.

In the early part of 2010, Dr. McCluskey and the anesthesiologist began monitoring these patients with the Somanetics Invos NIRS technology. The patients were pre-evaluated in the pre-op holding area both in the supine and sitting position. Frustration and questions occurred when patients were being cancelled because of extremely low readings. Many of these patients had no pre-existing co-morbidities that would demonstrate these findings. These patients were consequently arranged to have full cardiovascular and vascular studies performed for clearance for their surgery. One patient in particular was cancelled for a reading of 15 on both the left and right side.

He was a young gentleman who works in the field of aerospace design. His subsequent workups were negative.

Following this, Dr. McCluskey approached Perfusion.com (PDC) to set up an evaluation and further studies in assessing all the existing technologies of cerebral oximetry. All three cerebral oximetry companies were contacted to participate in this evaluation. Nonin, Somanetics, and CasMed all graciously came in to give a complete overview of their technologies to the board of physicians. All three corporations agreed to participate in the evaluation process. The evaluation was set up to evaluate and collect data on thirty patients, all arthroscopic shoulder repairs in the beach chair position.

There were twenty five Caucasians, four African Americans and one Hispanic. The age of the patients ranged from nineteen to eighty-nine years of age. Co-Morbidities included nine patients with diabetes, fifteen with chronic hypertension, and eight patients with sleep apnea. All three devices were measured in the pre-operative area, both in the supine and sitting position. Rotation of the monitors was established in order to measure and collect data on ten patients with each device in the intra-operative surgical arena. Data was collected in the surgical suite at baseline, pre induction and post induction. Also data was collected on the lowest values recorded and corrective action using the Denault treatment algorithm. A staff evaluation form was provided in order to receive direct feedback on sensor design, reliability, ease of use, functionality, and data management.

Remember the patient that had the fifteen reading on both right and left side? He was contacted and gladly came in for further evaluation using all three devices. The devices either did not give a reading at all or failed to provide a clinically meaningful reading on this young man. Computer models from one of the companies device showed that the light waves were entering the subject but were either being absorbed

C. Ty Walker, CCP, PBMT

Director of Perfusion
Services and Blood
Management

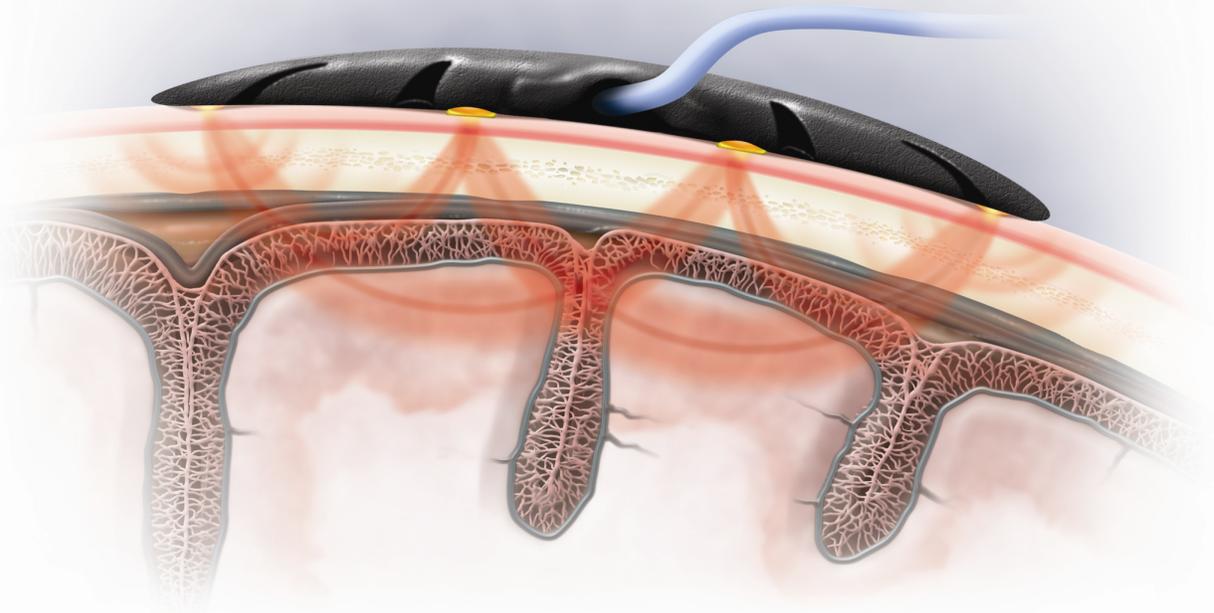
Perfusion.com

or fragmented and therefore their systems was unable to obtain an adequate signal for measurement.

These findings led to a lot of unanswered questions. What unknown patient factors are affecting the rSO₂ readings? How do we as practitioners move forward with the patient care when low rSO₂ reading occur? How would we avoid legal ramifications if we were to proceed? Will new technology rectify these encountered problems?

Near the end of this evaluation process, Nonin announced the release of a new four wavelength sensor for their Equanox monitor. Nonin stepped up to the plate and hit a

grand slam with their new "Advance" fourwave length sensor. For the fourth time our dedicated patient, now a friend, returned to be put to the test. His quote when he came " I want to help in understanding this technology and hopefully improve patient care and outcomes for those patients in the future". Low and behold the new Equanox Advance four wavelength sensor worked where no other system had worked before. With this system the patient readings were 54 on the left and 56 on the right. Had this technology been available at the facility at the time of his surgery, the case would not have been cancelled nor the patient put through the ringer with expensive workups.



Why did the Nonin Equanox four wavelength sensor work where other systems were unable? We believe the answer is a combination of factors that all work together:

- The four wavelengths allow for removing variations in light absorption and fragmentation
- Dual emitter/dual detector sensor design minimizes effects of shallow tissue
- Highly refined signal processing algorithms that minimizes noise
- Advanced ambient light tolerance

Combined, these factors provide for a technology that allows reliable performance in the most challenging patients and conditions.

Finally, I would like to summarize the results of our evaluation. On a scale of one to five and five being the best, the Nonin device overall score was 4.9 - a point and a half higher than any of its competitors. Reviewing all data collected on the thirty patients the Nonin device had minimal variations or outliers, and provided superior correlations during the procedures. Further details of this evaluation study will be presented at the AmSECT meeting in April, 2011.

We finalized the evaluation by bringing the initial physician board back in to review the results of our evaluation on

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Isoflurane Vaporizer Failure on Bypass: An Investigation

An incident occurred during a heart transplant at UPMC Presbyterian Hospital in Pittsburgh, PA that was particularly instructive to a nascent perfusionist. After initiating CPB and establishing a stable flow rate, the first blood gas on bypass revealed that the paCO_2 was alarmingly higher than normal (82mmHg) but the patient's concurrent oxygen status was adequate (paO_2 : 359, SVO_2 : 81). The gas flow rate (GFR) was immediately increased from 3.6 L/min to 6.0 L/min. to ameliorate CO_2 ventilation. A repeat blood gas sample was promptly analyzed and, instead of the CO_2 becoming lower as was expected, it was even higher (98mmHg). Naturally, the high CO_2 was accompanied by extreme acidosis (pH 6.95) and a severe base deficit (-12.0). These alarming values prompted quick action, so while sodium bicarbonate was administered, preparations were made to transition gas support to the portable tank. A senior perfusionist was also summoned to the OR to assist. She evaluated the situation and quickly assessed that a faulty isoflurane vaporizer was most likely the cause and directed that the isoflurane vaporizer should be disengaged. After switching the vaporizer off, a subsequent blood analysis revealed that paCO_2 was returning to a more desirable value (48mmHg). It seemed clear that CPB must proceed without the use of the isoflurane vaporizer. The attending anesthesiologist was notified that isoflurane could not be provided for anesthetic support on pump and he agreed to compensate with alternative amnesic drugs.

The patient's blood gas values were eventually restored to normal ranges and the case concluded without any further difficulties. The blood pH and paCO_2 had ultimately been restored through proper ventilation and the base deficit was also within an acceptable range for CPB (-2.4). The heart transplant was an apparent success upon terminating bypass, with excellent cardiac function and acid-base status.

Despite the favorable outcome, the mechanical breakdown of the gas flow remained a curious dilemma and the precise cause of

the failure was more thoroughly investigated. A series of ad-hoc tests were performed on the gas flow line in the OR during the post-CPB period. In order to evaluate the malfunction, the ventilation rate on the blender was increased while the vaporizer was turned off and the outlet was manually tested for air flow. At a rate of 10L/min. air could be felt vigorously flowing from the end of the gas line that was connected to the oxygenator. After activating the vaporizer, even slightly, the gas flow out of the blender ceased almost entirely, and was not restored until the isoflurane vaporizer was again turned completely off. The test was repeated several times at variable settings of the isoflurane dial. All of the tests led to the same conclusion: that the isoflurane vaporizer was indeed the faulty component in the gas flow circuit.

After the case, the vaporizer was tagged for service with details of the malfunction and the entire pump assembly was sent to the clinical engineering staff for evaluation and repair. The pump was returned with a replacement isoflurane vaporizer; however the engineers could not duplicate the malfunction on the original equipment and were unable to offer a concrete explanation for the interruption to gas flow. With a new vaporizer in place, the problem seemed to have been resolved and no further information regarding the state of the malfunctioning equipment was reported. In the interest of education, a

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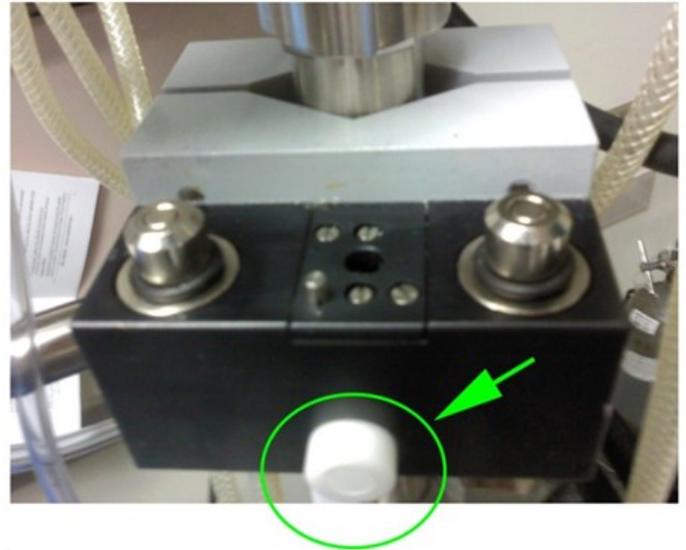
more thorough investigation of the vaporizer and components was initiated to better understand the exact cause of this ventilation failure.

The vaporizer used on this particular case was a Datex-Ohmeda Tec 5 Continuous Flow Vaporizer, commonly incorporated into anesthesia workstations for in-line anesthetic gas delivery while ventilating the lungs. Like other vaporizers of its kind, this particular model uses a wicking mechanism to add vaporized gases to the fresh air flow from the blender. By turning it counterclockwise, the rotary valve on the vaporizer allows for an increased concentration of volatile gas to be carried to the oxygenator through a tapered flow channel molded into the underside of the knob. This apparatus increases or decreases the gas flow through the internal wick assembly and thereby making the desired adjustment to the concentration of evaporated gas that is carried through the gas flow circuit. Greater air flow increases in depth within the hollow wicking coil and carries a higher concentration of evaporated anesthetic gas as it exits the channeled sump cover.

The mount specified for this model vaporizer is the Selectatec Series Mounted Manifold, which contains a built-in gas bypass manifold designed to operate with the Datex-Ohmeda Tec series vaporizers. When the knob is turned off on the vaporizer, the flow of air from the flowmeters is redirected through an internal bypass circuit in the manifold. Once the knob is turned on, even slightly, two port actuating valves are lifted upwards by a lever system mechanically activated by the knob. These port valve actuating spindles are aligned with spring-driven port valves in the manifold that, once released by the valve actuating spindles, are raised and redirect air flow from the manifold through the body of the vaporizer.

If the vaporizer is not properly seated to the Selectatec manifold and the actuating spindles are engaged by turning the control dial on, an incompetent seal between the port valve o-rings and the interlock block ports could allow air to escape. Likewise, the locking lever must be properly engaged to the locked position by pushing the lever completely down its vertical length before attempting to turn it. The vaporizer has a built-in safety design that prevents the check dial from turning on if the locking lever is not fully engaged.

There is a spacer attached to the Selectatec mount on the plane facing the vaporizer that keeps the mounting surface of the manifold aligned with the mounting ledge surface. This allows the interlock block ports to be properly seated. Without this spacer, the gap between the manifold mount and the back surface of the vaporizer can cause the vaporizer to sag due to gravity and as a consequence the horizontal contact surfaces on the mount and vaporizer would no longer be flush. This misalignment could reflect to the port valves which, with the housing of the vaporizer tilted, are no longer plumb with the interlock block ports. The skewed fit would create a small but sig-



The Selectatec single manifold used to mount the Datex-Ohmeda Tec 5 vaporizer; the arrow points to the spacer designed to keep the sump assembly from sagging.

nificant gap, large enough to allow copious air to escape. Since there are two of these connections in the assembly, the pressure would leak from both of these improperly aligned fittings, essentially doubling the loss of air pressure. Problems with improperly assembled spacers have been reported in the older models of these vaporizers (Tec-3 and Tec-4 particularly), however, the design of the Tec 5 does not allow the spacer to be removed from the housing and it was found to be free of any serious wear that would alter its function.

The vaporizer has an internal thermostat within the vaporizer housing that partially redirects gas flow, and this was initially a suspected cause of the failure. However, further scrutiny revealed that the thermostat merely regulates the proportion of fresh gas added to the total air mixture of gases via a bifurcating bypass channel built into the outer sump housing. Fresh gas flow is added to the vaporized content and either increased or decreased via a bimetallic strip to offset changes in vapor pressures of the anesthetic gases that occur at variable temperatures. The thermostat alone will not totally occlude gas flow through the vaporizer.

The port valves should be precisely aligned and seated before locking the vaporizer into the manifold and the o-rings should be periodically inspected for wear, cracks and proper fit. A repeat test for gas flow with the o-rings removed produced a significant leak from the interlock block ports. The condition of the o-rings was not examined prior to sending the unit for maintenance, so a fault with the o-rings cannot be verified. Yet, such a fault was easily reproduced. At a setting of 10L/min. on the

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SeChrist blender with the o-rings removed and the vaporizer mounted, there was virtually no air pressure at the outlet and, with the outlet occluded, the air leak from the port valves was audible. At a flow of 6L/min. there was still no flow at the outlet but the leak at the manifold was still audible but very faint. This trial was conducted in an unoccupied OR after normal operating hours and it stands to reason that during a fully staffed surgery with the pump and multiple other machines in operation, this sound would be virtually imperceptible amid the ambient noise.



A closer examination of this particular manifold revealed that the left port valve was loose and could be removed by hand, as opposed to the right port valve which was tight and could not be turned at all. Opening the port valve exposed its internal mechanism, which consists of a steel ball suspended between two vertical springs, a vented brass ring, a plastic washer and a rubber seal. The springs are seated in fitted channels that allow the ball to move up and down, which alternately occludes air flow to through the manifold or vaporizer. Gas flow was tested with the port valve partially unscrewed and the vaporizer mounted. Gas flow from the outlet at the oxygenator was all but completely absent. Even at the maximum flow rate of 10L/min. the air felt coming from the end of the gas tubing was minimal and when occluded the air leak could be heard escaping from the port valve. The test was repeated with the port valve unscrewed at variable intervals and in all cases there was a correspondingly diminished air flow. It was only when the port valve was completely tightened that what seemed to be normal air flow was restored and no leak from the manifold could be detected. This is perhaps the most conclusive finding to explain the possible cause of the failure while on pump. It was surprising that the va-

paporizer could be mounted with one port valve loosened and raised. The difference in height between the two port valves seemed significant but did not prevent the interlock block ports from seating and locking into place. Such a mechanical deficiency could have been easily overlooked even if the vaporizer was dismounted and inspected.

The most insidious aspect of this malfunction was that, despite an inadequate ventilation flow rate, there was still sufficient oxygen content delivered to the blood. While paCO_2 levels rose significantly, they were not accompanied by equivalent decreases in PaO_2 . Even when the PaCO_2 was at its highest (98mmHg), the PaO_2 was relatively normal (200mmHg) for CPB. This could easily be attributed to patient cooling (the temperature of venous blood at this point was 31.3C) or to a decreased O_2 demand from anesthetics, but nonetheless, during the crisis of interrupted ventilation, the patient seemed to be receiving adequate oxygen supply. Even the venous saturation monitor confirms this, since the lowest PvO_2 , coinciding with the highest PaCO_2 of 98, was recorded at 67mmHg, not too far off from the normally desired concentration. Another explanation could be that the isoflurane was set to 2.0% at the onset of CPB to counteract high starting pressures. This could have increased gas flow slightly, providing improved oxygen flow but insufficient air pressure to eliminate CO_2 . The increased flow rate through the vaporizer may have allowed enough oxygen to be carried with FiO_2 set to 100% upon initiation.

To prevent this type of situation in the future, the first and most important step is knowing that the vaporizer can interrupt air flow to the oxygenator. The easiest fix for this malfunction, should it reoccur, is to turn off the isoflurane vaporizer and conduct the case without anesthetic support from the pump. However, if the perfusionist is unaware that the vaporizer can occlude gas flow, this may not present itself as an immediate solution. Education and awareness are key to preventing patient injury. Testing gas flow with the isoflurane vaporizer engaged would help to check the integrity of the entire gas flow circuit. The addition of aspirating oxygen analyzers into the gas circuit between the oxygenator and the vaporizer is one strategy for monitoring adequacy of gas flow, but according to some experts, this is not enough to ensure proper ventilation. The use of a pneumotachograph to monitor ventilation pressures while on bypass has been recommended by Kirson and Goldman in a 1994 article in the *Journal of Cardiac Anesthesia* (1:51-7). As demonstrated, this was the experience during this case, since the patient was receiving adequate oxygenation but improper ventilation. More routine inspection of the mounting position, visual inspection of the port valve seals and compliance with scheduled maintenance will also serve to prevent sudden vaporizer calamity. The vaporizer and mount design are such that they do not ordinarily demand frequent maintenance, but Datex-Ohmeda indicates that a complete recalibration of the vaporizer no less than every three years is recom-

mended, regardless of condition or function, to include a complete disassembly and replacement of the wick and seals. No service manual for the Selectatec mount could be obtained, but should be part of the routine inspection and maintenance schedule. Finally, a properly calibrated in-line continuous blood gas analyzer, though expensive and typically reserved for more complex procedures, would have alerted the perfusionist to the incremental rise in PaCO₂ and probably elicited a more rapid response to the predicament.

In summary, the isoflurane vaporizer presents a variable yet necessary divergence to a seemingly otherwise simple and direct gas flow circuit. This investigation has yielded a better understanding of the vaporizer mechanics in the gas flow circuit as well as an improved appreciation for the importance of the ventilation component of blood management while on CPB. The functional integrity of the apparatus relies upon a number of seals and locking mechanisms, all of which depend upon an air-tight contact in order to preserve continual, pressurized gas flow delivery. A significant air leak due to a faulty connection, corroded or improperly seated seals or mechanical misalignment could result in a disruption of gas flow, decreased gas pressure and ultimately a lack of respiratory ventilation. Awareness that the vaporizer can fail is an important consideration for any perfusionist since it could occur again in the future. Knowing the full range of possible equipment failures than can occur and how to react appropriately is fundamental to a perfusionist's success.

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Cerebral Oximetry

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cerebral oximetry. All six physicians unanimously voted to move to the new Nonin Advance Equanox technology due to the accuracy, reliability and user satisfaction to best provide service for our patient population.

In conclusion, I would like to stress to the reader audience that all devices are not the same and that each facility can and should undertake their own evaluation of competing technologies to assess what will meet their individual facility and practice needs. It should be noted that assessment of true clinical accuracy is complex and likely not feasible in the typical clinical arena given it requires both jugular bulb venous blood sampling and patients to be maintained in a stable state. However, other factors - signal integrity, interface factors, functionality - can easily be assessed as we did in this trial. As I mentioned earlier, this trial was done with the knowledge and cooperation of all three companies. Our goal was to better appreciate the technology capabilities and potential and to identify an optimal solution for our practice.

Again, I would like to thank each company for their support and also the patient that dedicated his time to this endeavor.

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The Call for Improved Technologies for Perioperative Temperature Management

Clinical research has demonstrated that safe and effective thermal management of cardiothoracic surgical patients improves outcomes.¹ The prevention of hypothermia during cardiac surgery has been proven to result in fewer transfusions, less post-operative bleeding, less time on mechanical ventilators, less time in intensive care, and faster discharge from the hospital.² However, traditional thermoregulatory techniques such as forced air warming and warmed intravenous fluids, often do not reliably maintain core body temperatures during long and complex surgeries.¹

In 2009, the Centers for Medicare and Medicaid Services (CMS) announced a new reporting requirement metric which is aimed at increasing the number of patients who leave the OR normothermic (a temperature of 36° C or greater). In all surgeries longer than one hour, normothermia must be recorded in the last 30 minutes before anesthesia end-time or 15 minutes after end-time. This specification is important because it means that hospitals are now required to use active warming practices or demonstrate normothermia in order to avoid negative Medicare reimbursement repercussions.

Even mild hypothermia (-1.5°C) can cause adverse outcomes and complications such as increased infections, cardiac dysfunction, coagulopathies that result in blood loss, altered drug metabolism, delayed recovery time and in some instances increased mortality. These adverse outcomes can cause additional hospitalization costs averaging \$2,500-7,000 per patient.²

The Challenges in Maintaining Normothermia

Hypothermia occurs in the majority of surgical patients as a result of anesthesia. Anesthetic agents cause vasodilation which allows heat from the core of the body to be distributed to the periphery, which causes the core of the body to cool. Cardiac surgery in particular poses distinct challenges to perioperative temperature management. Both on-pump and off-pump procedures are typi-

cally long and large areas of the patient's body, including vital organs, are exposed to room temperature leaving relatively little body surface area available for warming. In a recent study, almost 50% of CABG patients were hypothermic.³

In addition, the use of deliberate patient cooling during CABG creates the need to rewarm patients post-operatively without causing hyperthermia. This is important because of the danger of cerebral injury due to hyperthermia. In order to reduce the risk of neurocognitive decline post-CABG, re-warming must be carefully controlled and monitored during the post-operative process.⁴

A large, retrospective study of 5,701 patients who underwent CABG surgery found that the 1,598 patients classified as hypothermic (<36°C) on admission to the intensive care unit (ICU) had significantly higher mortality ($P=0.02$), required significantly more units of packed red blood cells ($P<0.001$), had significantly longer stays in the ICU ($P=0.01$) and hospital ($P=0.005$), and required mechanical ventilation for longer times ($P=0.07$) than did the 4,103 normothermic patients (>36°C). The negative effects of lower temperature on outcomes remained even when extreme temperatures were excluded from the analyses.⁵

A complicating factor in patient temperature management is that temperature measurement devices and locations may not accurately reflect core temperature values. Clinical research has shown that the sites that most accurately reflect core temperature are the pulmonary artery, distal esophagus, nasopharynx and the tympanic membrane. However, each of these sites may not be accessible during surgery and the accuracy of temperature readings may be compromised. This leaves the clinicians with a complex decision-path for appropriate patient warming, which includes factors such as multiple conflicting temperature measurement, bladder output, patient characteristics, etc.

Several review papers have characterized the risks of inadvertent hypothermia in OPCAB surgery. Intentionally induced hypo-

thermia and the unavoidable cooling of the body during these long, complex procedures are additional complications. During CPB, the open thorax and the use of extremities for vessel harvest works against thermoregulation via the cardiopulmonary bypass pump, and limits the surface area of the body available for patient warming. For these and other high risk procedures, there is a clinical need to use patient warming devices that provide efficient heat transfer while minimizing the risk of adverse thermal events.

There are also process and logistical issues that can impact the efficacy of thermoregulation measures. The first issue is that despite its importance, temperature management may not be considered a priority by clinicians. This may be because of the inherent complexity of a procedure or because there is an incomplete understanding of the mechanism of hypothermia and the proven negative effects on patient outcomes.

Temperature management practices also vary from institution to institution. Inconsistent practices within healthcare institutions also exist regarding the prevention of hypothermia, which can lead to confusion. In some operating rooms or for some procedures, thermoregulation maybe considered a priority whereas in others, temperature management may hardly be considered. These inconsistencies, along with the fact that the benefits of warming are not immediately apparent, may cause clinicians to give it less consideration than is warranted. Staff turnover in the healthcare setting also contributes to inconsistent thermoregulation practices. When an individual practitioner leaves who has historically led a team's efforts to prevent hypothermia, the result can be a lack of focus on the issue.

What Can We Do?

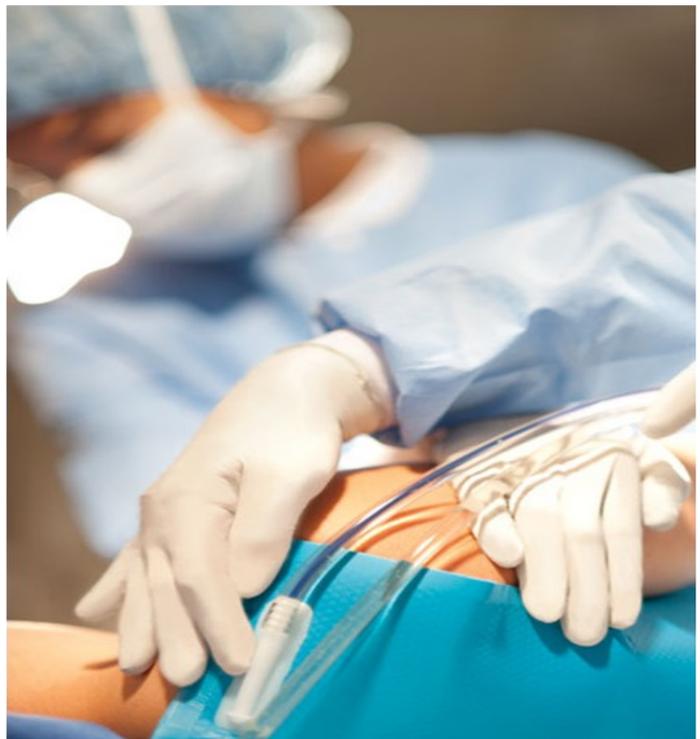
The optimal approach to perioperative temperature management is to prevent patients from ever becoming hypothermic. However, misconceptions exist about the efficacy and limitations of patient-warming methods, even in institutions that are well aware of the benefits of normothermia. There is also a lack of clear, evidence-based guidelines on how to best warm patients.

Conventional warming techniques such as raising the ambient temperature in the operating room or using warm intravenous fluids do not provide clinicians with the ability to precisely and flexibly control patient temperature. Other devices such as sterile, forced-air warming blankets compromise the surgeon's flexibility and access to the surgical field when used on the upper body during a cardiac procedure, and can interfere with the vein harvesting field when used on the lower body. In addition, these blankets are not adequate when used exclusively on the lower body.

The Right Choice

The Kimberly-Clark* Patient Warming System provides many clinical benefits for non-invasive thermal management in complex surgeries such as cardiovascular procedures. In clinical trials, The Kimberly-Clark* Patient Warming System significantly outperformed conventional warming techniques (twice as efficient as forced air warming) in achieving and maintaining normothermia. The system's automatic, computer-controlled algorithm avoids warming patients above normal range and can help prevent undesirable temperature spikes – both high and low.

The Kimberly-Clark* Patient Warming System consists of two simple elements: A small, portable, easy-to-use control unit that circulates heated water through innovative thermal hydrogel pads applied to the patient's body. The Control Unit is small and portable, and features a user-friendly interface for programming precise automated or customizable patient temperature management. A standard temperature probe may be connected to the patient and the control unit, creating a feedback loop by which water temperature may be automatically adjusted to optimize the patient's target temperature. The unit's negative pressure design is designed to avoid accidental leaks if the pads are nicked or cut during the procedure.



Application of Patient Warming System Pads

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The Control Unit is features a user-friendly interface for programming precise automated or customizable patient temperature management.

The advanced, non-slip, hydrogel thermal pads provide an optimal energy transfer path to the patient. The disposable pads conduct heat directly through the skin, safely maintaining normothermia using only 20% of the patient's surface area. The pads feature a thin, conformable, foam and gel construction that provides direct thermal conduction between the warm water flow path and the patient. Various pad sizes allow placement on many body surfaces, making the system ideal for a wide variety of patients and surgical procedures.

The system can be managed manually or can be allowed to automatically control a patient's temperature to a set point using the remote interface. In automatic mode, the control unit analyzes the patient's rate of temperature change and automatically adjusts the water temperature to achieve a clinician-defined patient target temperature. The Kimberly-Clark* Patient Warming System does not disrupt grounded signaling systems, physiological monitoring systems, electro-surgical units or defibrillation devices.

Improving Patient Outcomes

Patients who do not experience hypothermia during surgery require fewer transfusions, experience less post-

operative bleeding, spend less time on mechanical ventilators, require less time in intensive care, and go home sooner. Patients who are kept normothermic are also easier to manage, shiver less and rarely require additional warming. Use of the Kimberly-Clark* Patient Warming System has resulted in a 40% reduction in time to extubation; a 35% reduction in ICU stays; and a 15% decrease in length of hospital stays versus conventional techniques.¹ A cost-benefit analysis also revealed that hospitals can save up to \$743,570 per year using the Kimberly-Clark* Patient Warming System in place of current practices. The Kimberly-Clark* Patient Warming System offers a cost-effective alternative for patient warming during cardiac cases.

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The Kimberly-Clark* Patient Warming System circulates heated water through innovative thermal hydrogel pads applied to the patient's body.

Please contact TempMgmt@kcc.com or access www.kchealthcare.com/warming for further information.

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MEMBERSHIP DEADLINE	November 26, 2011
PRE-REGISTRATION	January 5, 2012
HOTEL REGISTRATION	January 5, 2012
2012 ANNUAL MEETING	January 26 - 29, 2012

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as part of the 2011 American Association for Thoracic Surgery (AATS) Annual Meeting
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