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PREMIER ISSUE

NEONATAL CEREBRAL FUNCTION MONITORING

By Alan R. Spitzer, MD

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Cerebral function monitoring (CFM) represents a novel technology in the care of neonatal patients that has recently gathered a significant amount of attention as a valuable addition to the diagnostic tools available in the NICU. Although used since 1969 in adults[1], and since 1983 in neonates in Europe[2][3], the value of this device has been disclosed only recently during its use as one of the qualifying criteria in the brain cooling trials for hypoxic-ischemic encephalopathy (HIE) during the neonatal period[4]. From these studies, it became evident that the potential utility of CFM extended far beyond this specific purpose.

CFM, also known as integrated, amplified electroencephalography, or aEEG, represents a bedside, readily available, user - friendly technology for the detection of brain wave activity and the diagnosis of seizures. Through the application of two scalp electrodes that are placed in the temporal-parietal region of the scalp bilaterally and a ground electrode (Figure 1), measured electrical signals can be detected, amplified, integrated, and recorded, yielding valuable information about the overall integrity of the neonatal central nervous system. The use of the device at an infant's bedside is demonstrated in Figure 2.

Although many of the studies to date that have examined the role of CFM monitoring have focused on the infant with HIE[5][6], other studies have evaluated the maturing brain and the changes that occur in the aEEG during post-natal development, especially in the premature infant. In both instances, CFM recording has been shown to add significantly to the clinician's ability to define the potential of an infant for normal

Figure 1. (Figure Courtesy of Bob White, MD). Placement of aEEG scalp electrodes and ground electrode. The single ground overlies the frontal region of the scalp, while the recording electrodes are placed in the temporal-parietal region bilaterally).

Figure 2. Olympic Medical 6000 Cerebral Function Monitor at an Infant's Bedside.

development or the possibility of subsequent neurological abnormality. With its growing popularity, CFM will continue to reveal additional insights into the factors that most directly influence neurodevelopmental outcomes in the neonatal population.

The purpose of this paper is to describe the aEEG recording that is obtained during CFM monitoring and to show how it can be used in the management of the pre-term and term infant.

The aEEG Recording

The typical aEEG study is a two channel recording that measures two values primarily (Figure 3). The tracing shown is from an Olympic 6000 cerebral function monitor (Olympic Medical, Inc. Seattle, Washington). While there are several outstanding devices currently available for CFM recording, the author's experience has been primarily with the Olympic Medical analog Lektromed device and the newer digital Olympic 6000, so that the studies shown will reflect the superb results available from these units. Following careful preparation of the scalp, and the placement of either very tiny needle electrodes or gel electrodes in the regions previously noted, the following signals can be shown:

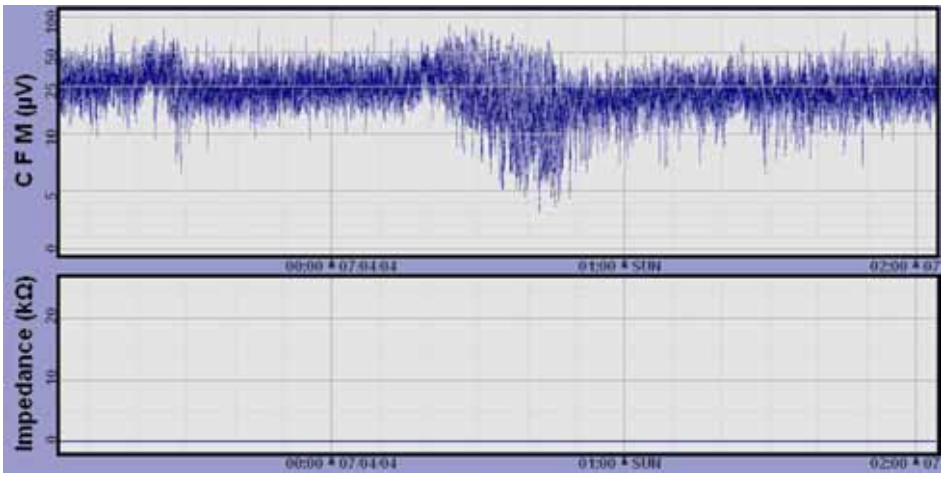

Figure 3. Olympic CFM 6000 Recording (courtesy Ted Weiler, Olympic Medical) The top channel indicates the aEEG in values from 0-100 mVolts, while the bottom channel demonstrates the impedance from 0-25 kilo-Ohms. The aEEG recording is very healthy appearing, with a baseline that is over 5 µV during most of the tracing period, except for a normal segment of cycling. There is no change in impedance throughout the recording and the impedance is very low, indicating a high quality signal for the aEEG.

1) The integrated brain wave signal in microvolts on a semi-logarithmic scale, ranging from 0 to 100 mV; and

2) The degree of electrical impedance, on a scale of 0 to 25 kilo-ohms. The impedance demonstrates the quality of the signal that is being received. If impedance exceeds 20 kOhms, the device will set off an alarm to alert the caregiver that the signal is not longer being adequately detected. In most instances, increased impedance reflects a loose lead that needs repositioning.

The impedance channel can be replaced at any time by a raw, scrolling EEG recording, which is particularly valuable when one attempts to determine if a seizure has occurred at any time during the evaluation period (Figure 4).

There are several characteristics of the aEEG tracing that are typically examined:

1) Continuity of the signal

Continuity refers to the consistency of electrical activity. A continuous trace has continuous electrical activity so the CFM trace never goes below about 5 µvolts. A discontinuous trace will have periods of very low, or no electrical activity, allowing the lower margin of the CFM trace to drop below 5 µvolts. Immature infants and infants with HIE will typically have periods of discontinuity, primarily due to the fact that the central nervous system activity is highly variable. There may also be greater numbers of peaks and troughs in the recording, again suggesting the inconsistency of the brain's electrical output during this time period.

2) Bandwidth of the recording

Bandwidth is examined for a number of specific characteristics. In a healthy,

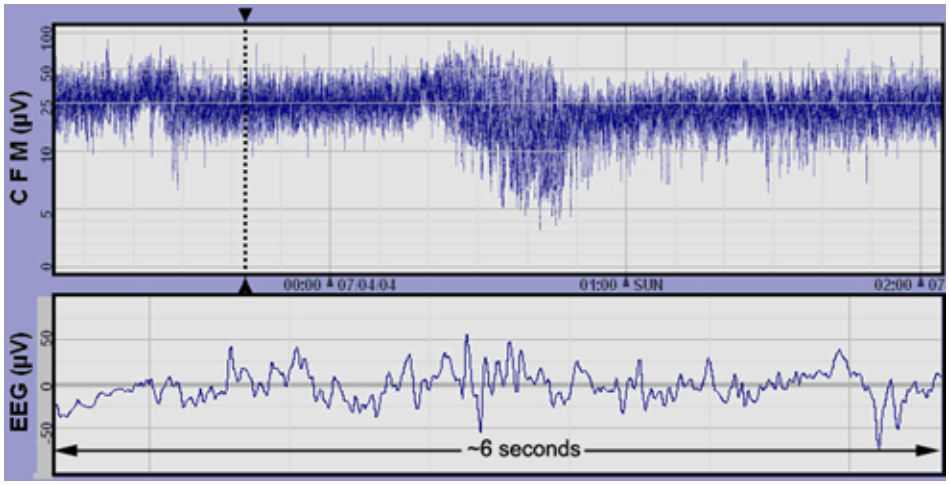

Figure 4. (Courtesy Ted Weiler, Olympic Medical) A CFM recording in which the lower channel has been replaced by a continuous EEG tracing, taken at the point of the dashed line in the upper, aEEG recording.

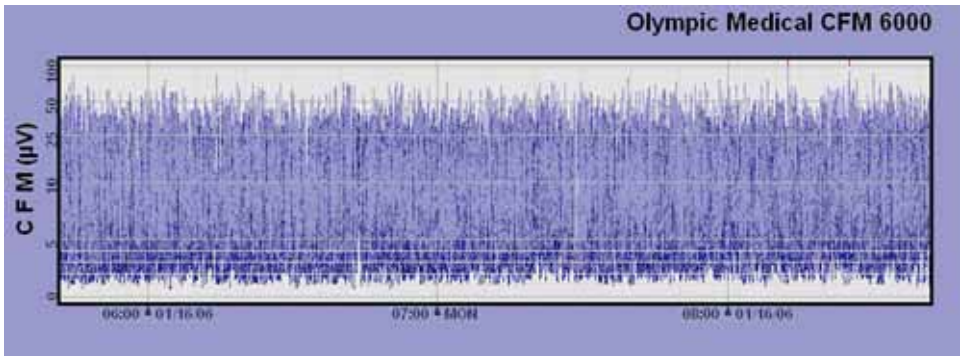

Figure 5. (Courtesy Ted Weiler, Olympic Medical) A CFM recording in a child with hypoxic-ischemic encephalopathy that demonstrates a broad bandwidth and an extremely low margin residing near 0 µV at the baseline.

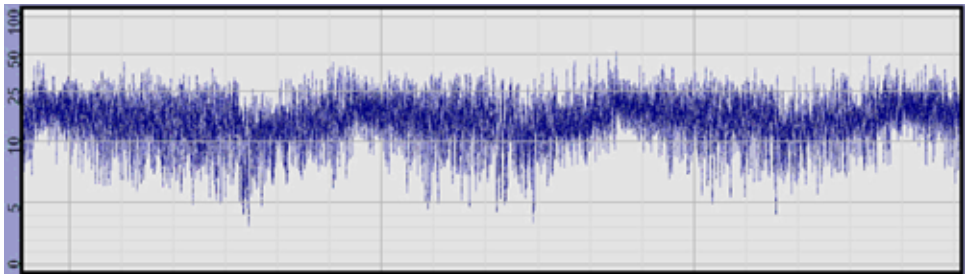

Figure 6. Cycling in a healthy infant. The baseline is well above 5 µV and narrow, except for the periods during which the tracing widens and descends slightly. This is considered to be a normal, healthy pattern.

normally-developing brain, the lower margin of the dense section of the tracing should reside above 5 µV. Extremely premature infants and term infants with HIE will have a lower level less than 5 µV, reflecting periods of diminished electrical activity in the brain. As a healthy child matures, the bandwidth will continue to rise further from the baseline. The bandwidth will also become increasingly narrowed with normal maturation, whereas it will continue to demonstrate a greater spread in the infant who is not developing appropriately. An abnormal bandwidth is shown in Figure 5, in contrast to the healthier bandwidth appearance of the child seen in Figure 3.

3) Cycling of the recording (Figure 6)

Cycling refers to alterations in the height of the bandwidth and the span of the bandwidth that occur in a recurring manner throughout periods of the recording of a well infant. Although cycling is often referred to in the literature as sleep-wake periods, it is not clear that the epochs during which the recording widens and the baseline lowers do, in fact, reflect a true sleep state. These periods may, instead, simply reflect changes in brain activity or a maturational period during which the aEEG signal is slightly less well organized. Although the signal does deteriorate to some degree during cycling, cycling itself appears to reflect healthy brain development and is viewed as a very positive sign. Infants without cycling (Figure 5) either are very immature or have suffered some degree of injury. The child with an intraventricular hemorrhage (IVH), for example, may lose the ability to manifest brain cycling, as is true for the infant with HIE.

4) Seizures

Seizures often represent ominous events for the neonate. Although seizures can be a consequence of a temporary abnormality during the neonatal period, they often pose significant long-term issues for the neonate, depending upon the etiology of the seizure. In the CFM recording, seizures typically are revealed as a sudden rise in the aEEG. They may be very brief in duration, and these periods may be difficult to capture visually without the assistance of the scrolling EEG on the bottom of the CFM tracing. Typical recurring seizures are demonstrated in Figure 7.

5) Severe hypoxic-ischemic injury (Figure 8)

In the presence of severe neurological injury, markedly diminished overall brain activity may be seen. The overall bandwidth is greatly reduced, the recording rests upon the 0 µV baseline, and periods of sharp, brief spikes may be noted. These recordings have highly ominous implications for the neonate, and it is not uncommon for a significant percentage of these infants to either die or manifest profound long-term neurological handicap.

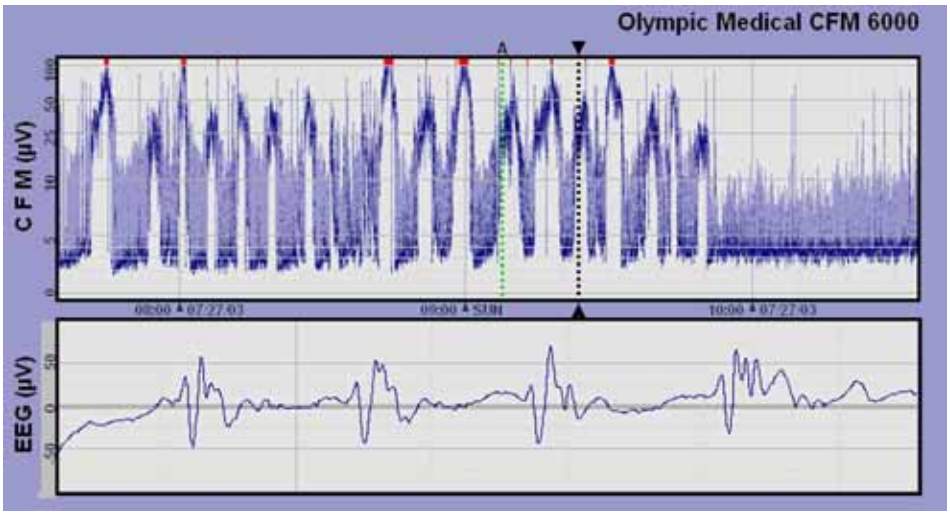

Figure 7. (Courtesy Ted Weiler, Olympic Medical) Recurring seizures on the aEEG recording in a term infant with hypoxic-ischemic injury. Seizures, with elevation of the entire recording, are seen throughout the aEEG tracing. The lower recording shows the classic spike and slow wave appearance of a seizure in the bottom part of the recording. The EEG recording reflects a six-second time duration at the point of the black dashed line seen in the upper recording.

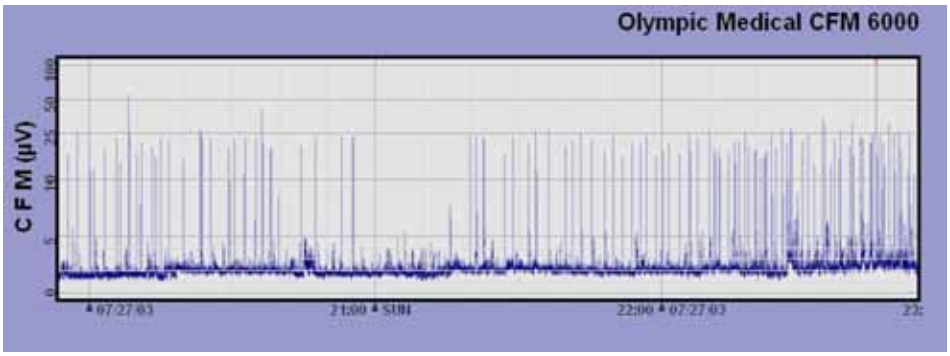

Figure 8. (Courtesy Ted Weiler, Olympic Medical) Severe hypoxic-ischemic injury with burst-suppression on the aEEG recording. Little cerebral activity, low baseline, and frequent spikes are seen.

Use of the CFM Recording

As indicated in the descriptions of the recordings, the CFM monitor can be used in a variety of ways in the assessment of neonatal neurological development and injury. Most studies to date have focused upon the child with hypoxic-ischemic injury. With HIE, the term or near-term infant's aEEG patterns reveal the following sequence of events with progressive injury:

1) Loss of cycling

2) Broadening of the bandwidth and reduction of the baseline level for the recording

3) Seizures

4) Burst-suppression appearance with decreased overall electrical activity and spikes

With recovery (though recovery may be limited with the severe forms of injury), there is a step-wise reverse change in the aEEG recording. The faster that this reversal occurs, the better is the long-term prognosis for the infant. A neonate who returns to normal cycling on the aEEG within 24-48 hours with baseline elevation above 5 µV has a much better prognosis than an infant in whom there is no reversal before 7-10 days. Infants who have had a difficult delivery, but who show few changes in their aEEG pattern, have a good prognosis overall.

In the pre-term infant, the aEEG is somewhat less well understood at the present time, since there is an interesting similarity of findings in the normal very immature infant and the child with HIE. More work needs to be done, however, to define the aEEG findings with respect to neurological abnormality and recovery from injury in premature infants.

The premature infant's aEEG patterns can, nevertheless, be examined for the rate of change expected in normal maturation. Burdjalov has described the events that occur during neonatal neurological maturation, as well as a scoring system which can be used to chart this maturation in the premature baby (Figure 9)[7]. Children with IVH appear to have a flatter slope and do not mature their aEEG patterns as rapidly, in general, as do preterm neonates without an IVH or PVL. More work needs to be done, however, as previously noted, since premature infants have not been extensively studied to date.

The CFM can also be used to follow the results of treatment with anticonvulsants in the case of neonatal seizures. Normalization of the aEEG is highly reassuring when a child has previously been diagnosed with a seizure disorder.

Summary and Speculation

The CFM recording appears to be a valuable addition to the armamentarium of the neonatologist in attempting to understand the factors that influence normal neonatal development, the severity of brain injury from HIE and IVH, and the likelihood of recovery from these entities. Further work is likely to reveal additional insights into brain development in the neonate with this device, and it is far from inconceivable that the neonate may one day be monitored for central nervous system integrity in the same way that we currently monitor cardiorespiratory changes in the heart and lungs. The aEEG appears to be an important tool that allows the neonatologist and neonatal nurse to better understand the changes that commonly occur in the brain during the neonatal intensive care hospitalization.

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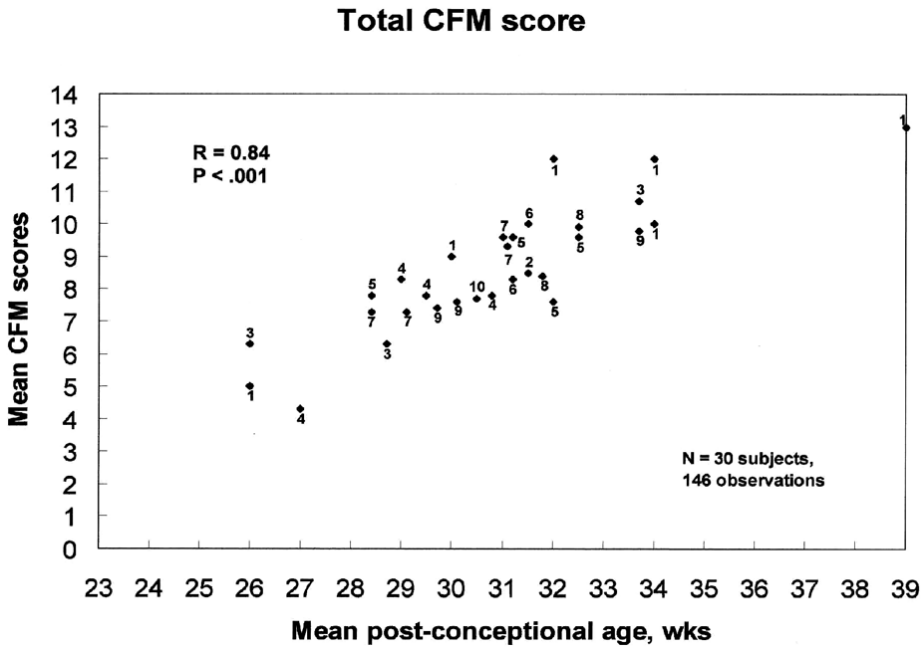

Figure 9. Scoring system for maturation in premature infants with aEEG recording. Reprinted with permission from Pediatrics (http://pediatrics.aappublications.org), Burdjalov VF, Baumgart S, and Spitzer AR: Cerebral Function Monitoring—a new scoring system for the evaluation of brain maturation in neonates. Pediatrics, 2003; 112: 855-861.

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List of Manufacturers of Neonatal Cerebral Function Monitoring Equipment

BrainZ Instruments Ltd.
www.brainz.com

GE Healthcare
www.gehealthcare.com

Olympic Medical
www.olymed.com/cfm/

Viasys Healthcare
http://tinyurl.com/h6d5y

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May 18-21, 2006; Marco Island, FL USA
www.southeastneo.org

3rd Annual Evidence vs. Experience Neonatal Practices
June 16-17, 2006; Boston, MA USA
www.5starmeded.org/neonatal

Obstetric Challenges for Contemporary Practice 2006
September 29, 2006; Denver (Bloomfield) CO USA
www.pediatrix.com

2006 AAP National Conference & Exhibition
October 7-10, 2006; Atlanta, GA USA
http://s12.a2zinc.net/clients/aap2005/aap2005/public/enter.aspx

Europaediatrics
October 7-10, 2006; Barcelona, Spain
www.kenes.com/europaediatrics/

NANN 22nd Annual Educational Conference—Neonatal Nursing Excellence: Growing and Knowing
November 8-11, 2006; Nashville, TN USA
www.nann.org/i4a/pages/index.cfm?pageid=803

30th Annual Neonatal International Symposium – Neonatology 2006
November 8-11, 2006; Miami Beach, FL USA
neonatology.med.miami.edu/conference/default.htm

NEO-The Conference for Neonatology
February 7-10, 2007; Orlando, FL USA
www.neoconference2007.com/

THE NEONATAL CARDIAC INTENSIVE CARE SERVICE: DEVELOPING A COLLABORATIVE NEONATOLOGY-CARDIOLOGY-NURSING TEAM IN THE NEONATAL INTENSIVE CARE UNIT

By Anthony C. Chang, MD; John Cleary, MD; Vijay Dhar, MD; and Dana Bledsoe, RN, MBA

Introduction

Cardiac intensive care has now emerged as a specialized clinical area focusing on the unique needs of critically-ill neonates with congenital heart disease[1]. Although an increasing number of pediatric cardiac programs have a dedicated cardiac intensive care unit and/or service, there are no published primers regarding logistical and organizational aspects of such a challenging endeavor. Some programs will continue to care for critically ill neonates with congenital heart disease in the neonatal intensive care unit. While there may be an ongoing debate about the preferred strategy in distributing clinical ownership of these neonatal cardiac patients, most authorities agree that a dedicated multidisciplinary team with a focus on critically-ill neonates with congenital heart disease is invaluable.

The three key elements essential for this service to be successful are teamwork, leadership, and change. One of the most important paradigm shifts in pediatric cardiac intensive care philosophy has been the deeper appreciation for teamwork and multidisciplinary involvement to include pediatric cardiology, neonatology, pediatric critical care medicine, cardiac surgery, cardiac anesthesiology, neonatal and pediatric cardiac nursing, respiratory therapy, and cardiac pharmacology. A multidisciplinary approach at the highest level eliminates conventional subspecialty boundaries and creates an egalitarian system to take full advantage of the expertise and experience of each subspecialty. This approach should not, however, be accompanied by dispersion of responsibilities and accountabilities. It is vital for any leader of the group to learn and appreciate group dynamics. For example, disruptive behavior of a team member is usually better treated as a team problem rather than as a personal issue. The leadership group needs to strive for a win-win situation in many scenarios that involve potential conflict [2]. Effective tactics for conflict resolution are well published and include: separating the people from the problem, focusing on interests rather than positions, inventing options for mutual gain, and insisting on using objective criteria [3]. As the neonatal cardiac intensive care service may need to be positioned to accommodate new types of patients, team learning becomes an essential aspect of this service. A recent review article in Harvard Business Review examining cardiac surgical teams learning a new technique revealed that important skills for leaders to foster team learning include: being accessible, seeking input from others, and being a fallibility model [4]. Both physician and nursing staffs should be encouraged to be involved in multidisciplinary research projects with guidance from the senior physician staff. Some of the research projects can easily be extensions of quality or performance improvement projects. It is of paramount importance to have mechanisms for both internal and external peer review on a periodic basis and to have a respected external expert to assess the program as an unbiased source of constructive criticism.

The physician and nursing leadership positions for this collaboration of care delivery are essential in order to achieve team cohesiveness and care consistency. The art of leadership is becoming a more focused topic in both the business and medical arenas[5][6]. Dealing with a group of physicians is usually a difficult endeavor and has been termed "herding cats" or "having eagles fly in formation." Leadership is about asserting influence (not control) and empowering all those around you to achieve their potential; this philosophy enables all members to have ownership in any group activity. This effort is facilitated by clearly delineating roles and delegating responsibilities while maintaining respect from all group members.

Although research in the business realm has demonstrated that organizations can undergo change in two ways (drastic action or evolutionary adaptation), smaller incremental changes in the neonatal cardiac intensive care setting to effect overall change may be more widely accepted than a major re-engineering strategy[7]. It is useful to have regular group meetings to monitor forward momentum so that all members of the group are accountable to progress. This progress needs to be measurable. All improvement projects should have the PDSA cycle: plan-do-study-act that is inherently familiar to the business world but not widely utilized in the hospital.

The Perspectives

The neonatologist perspective

Neonatologists within a division may have different levels of comfort and experience with congenital heart disease management. Training programs vary dramatically in the exposure to pre- and postoperative cardiac care and the trend towards dedicated cardiac intensive care units will exacerbate this problem unless training programs account for barriers to training. The care of patients with congenital heart disease involves the understanding of several important transitions. There is overlap between fetal physiology and extra-uterine life. There are interrelations between the infant's cardiovascular and pulmonary systems, and, perhaps, underappreciated is the overlap between medical disciplines in the optimal care of these fragile infants. The interrelation between neonatologists, cardiologists, critical care doctors and surgeons is addressed in the following paragraphs.

Prenatal diagnosis by fetal echocardiography is often reported to improve survival in patients with congenital heart disease. Twortetzy and colleagues[8] reported that patients with prenatal diagnosis of hypoplastic left heart had 100% survival after Norwood procedure compared with 66% survival in those diagnosed after birth. Neonatologists often have established relationships with ob-

stetricians and perinatologists and often are the first pediatric subspecialists to be informed about fetal diagnosis of congenital heart disease. Hence, they become instrumental in counseling mothers and families and triaging appropriate referrals to pediatric cardiologists and pediatric cardiac surgeons, and in arranging for prenatal transfers of such mothers to centers where delivery could take place in close proximity to a Level 3 neonatal intensive care unit with attendant pediatric cardiology and cardiac surgical services.

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New methodologies have led to significant progress in fetal electrophysiology increasing prenatal diagnosis of fetal arrhythmias as well. Treatment of fetal arrhythmias has been known to improve prognosis and prevention of significant fetal morbidity including hydrops. Effective cooperation of neonatologists with the pediatric electrophysiologist and perinatologist is key to better survival and prevention of morbidity of these patients with fetal arrhythmia. Emerging fetal cardiac surgery technology including balloon valvuloplasty and atrial septoplasty has been reported lately with improving success rates. Participation of neonatologists with pediatric cardiologists and perinatologists is again essential to the multispecialty team approach needed for these vital procedures to be successful.

In some cases of severe congenital heart disease or any disease expected to cause immediate deterioration after separation from the placenta, rapid invasive intervention may be necessary. This ex-utero intrapartum treatment (EXIT) procedure is designed with a goal to create hemodynamic and respiratory stability at delivery of infants who are predicted to have cardiopulmonary failure on separation of the placenta. The EXIT procedure has been successfully applied to fetuses as reported in a series of 31 neonates treated with EXIT procedure between 1996 and 2001[9]. Several studies have shown that location of delivery in tertiary centers could be beneficial for certain structural cardiac diseases. In a series of 110 prenatally diagnosed infants reported in 2001, researchers found that infants who had transposition of the great arteries frequently required invasive resuscitation not readily available at non-tertiary centers[10]. Close supervision and involvement of a neonatologist is important in making such important decisions.

Interdisciplinary coordination involving the neonatologist is essential in complete postnatal evaluation and workup of a baby with congenital heart disease. Three to four percent of children with congenital heart malformations have recognizable stigmata of various syndromes. These include Down syndrome, Turner syndrome, VATER association, velocardiofacial syndrome and many of the congenital malformations. The NICU team is important in integrating multidisciplinary care required to come to a more complete preoperative diagnosis for such babies.

In most cardiac programs, postoperative care of neonates undergoing open heart surgery or complicated closed procedures is dealt with in a pediatric or cardiac intensive care unit. The challenge of delivering quality care is exacerbated when care requires multiple transitions between services. At many institutions diagnosis and pre-operative management will happen in the NICU with the transfer of care to the critical care or cardiac intensive care unit team occurring surrounding surgery. The risk of such transitions must be recognized and is minimized by having cardiac team members active and visible in the NICU and neonatologists active in the cardiac intensive care unit. With a change in location and new care providers, there is often the potential to miss less critical features of a particular patient. This includes the potential to disrupt the relationship with the family and the healthcare team if one of the previous members of the provider team is no longer seen on the team. For this reason, the involvement of a neonatologist is desirable after surgery, even when the location of the patient has changed.

Nutritional support in babies with congenital heart disease presents a frequent challenge while continuing to be extremely vital in the overall outcome of patients with congenital heart disease. This includes a delicate balance in starting early trophic feeds to holding off on enteral feeds in an attempt to prevent necrotizing enterocolitis in certain cardiac lesions, especially in low birth weight babies. Many of these babies are managed on total parenteral nutrition and have and important need for certain nutritional and dietary manipulations. With extensive training in the supervision of the nutrition of low birth-weight and term babies, the involvement of the neonatologist and a neonatal dietician is essential in the overall management during hospitalization of any baby with congenital heart disease.

The neurodevelopmental aspects of hospital care for low birth-weight babies and term babies, and the important neurodevelopmental follow-up of babies with congenital heart disease is mostly supervised by a neonatologist in the hospital and in the neonatal developmental follow-up program. The emerging benefits of skin-to-skin care, kangaroo care, low level of ambient light, and ambient noise in the NICU contribute to the functional status, quality of life, and long-term developmental outcomes. These aspects of neonatal developmental care are often best supervised by a neonatologist in the intensive care settings of a cardiac intensive care unit or an NICU.

Additionally, neurodevelopmental sequelae in severe congenital heart disease are varied and do include motor delays, problems with learning disabilities, visual motor integration, as well as behavioral abnormalities including hyperactivity and inattention. A number of neurodevelopmental follow-up outcome studies of babies with congenital heart disease done in conjunction and collaboration with a neonatal developmental team led by neonatologists and ably assisted by cardiologists have shed im-

The multidisciplinary cardiac team at the Children's Hospital of Orange County.

portant light on the neurodevelopmental outcome of babies with congenital heart disease. These follow-up studies have been important in understanding the following: the neuro-development of the patient, social outcomes, the influence of our treatment, the overall outcome of improving our patient's quality of life and modifications of current techniques and management strategies for the overall and long-term good of babies with congenital heart disease.

In summary, with the advent of routine fetal echocardiography, the role of a neonatologist has become even more vital in coordinating and directing the care of mothers with known fetal cardiac anomalies. The role of the neonatologist starts fairly early with adequate and appropriate triaging of mothers of neonates with known congenital heart disease, coordinating and supervising their delivery and post delivery stabilization, and transporting and transitioning care of these critically ill neonates. The neonatologists are also involved in evaluating babies with complex cardiac diseases for surgery and in postoperative management of these babies with issues related to nutritional support and developmental follow-up of these neonates with congenital heart disease. Communication among neonatologists, cardiac surgeons, and cardiologists is of immense benefit to the patients and their families and for that matter benefit our own healthcare team. It is also emphasized that one of the neonatologists should continue to follow-up the baby after surgery, particularly as regards to the nonsurgical aspects of patient care in babies with congenital heart diseases.

The cardiologist perspective

Education for all members of the neonatal cardiac service is obviously a vital part of a neonatal cardiac intensive care program and demands constant attention. Special knowledge areas such as single ventricle pathophysiology, pulmonary hypertension, cardiopulmonary interaction, mechanical support usage, and complex tachydysrhythmias are particularly demanding and should be reviewed on a periodic basis with all caretakers. A geographical separation of a neonatal/pediatric cardiac intensive care unit is less important than the philosophical focus of a dedicated team to take care of neonates with critical cardiac disease. It is, however, logistically more sound to have these patients close together. The overall design of bed spaces needs to reflect specific needs of the neonatal cardiac patients[11]. The basic equipment and utilities, as well as laboratory and radiologic access for an intensive care unit, must be able to support the needs of the neonatal cardiac patients under normal and emergency situations (such as mechanical support).

"The care of critically ill neonates with cardiac disease provides a complex and unique opportunity to create a team dedicated to the care of these neonates, whether in a dedicated cardiac intensive care unit or within a neonatal intensive care unit."

Another important but understated concept is that cardiac intensive care should be delivered as a service continuum, and not merely as postoperative care after a surgical or interventional procedure. While there are generalized principles in neonatal cardiac intensive care, one must maintain an individualized approach to delivering care. Strategies for neonatal cardiac intensive care should include indoctrination of anticipatory, rather than reactive, care. A gradual transition from substantial cardiopulmonary intensive care support to the beginning of convalescence is preferred over abrupt changes in pharmacological and ventilatory management.

For a team of physicians to collaborate well together taking care of neonates with congenital heart disease in the neonatal intensive care unit, it is essential for neonatologists to be current in the knowledge of the latest survival statistics of common surgical and catheter procedures (such as the Norwood operation). In one study, neonatologists are least likely (compared to cardiac surgeons, cardiologists, and intensivists) to recommend surgery in neonates with hypoplastic left heart syndrome[12]. It is important to discuss management plans with parents with a consensus, as much as possible.

There also needs to be a free exchange of ideas and expertise among the subspecialists on a daily basis. Recent collaborative research projects have bene-

fited from input from both cardiology and neonatology; examples include a case series on bronchopulmonary dysplasia and cardiac surgery and a case report on serial B-type natriuretic peptide measurements in neonatal heart failure [13][14]. Lastly, there will be debate whether there can be some crossover in expertise, such as neonatologists performing basic echocardiograms[15].

The nursing perspective

The care of critically ill neonates with cardiac disease provides a complex and unique opportunity to create a team dedicated to the care of these neonates, whether in a dedicated cardiac intensive care unit or within a neonatal intensive care unit. This patient population requires a blend of expertise from both neonatal and cardiac intensive care nursing to meet the comprehensive demands of this complex patient. Furthermore, it necessitates a strong relationship between neonatology, cardiology and often cardiac surgery. Such dynamics create a rare practice environment with multiple stakeholders.

The clinical practice councils provide a great forum for multidisciplinary collaboration. Pertinent topics can range from issues related to specific patient care topics, standardization of care and orders, protocol development, performance improvement projects, review of program outcomes, staff development, as well as discussions about program growth and development. The underpinnings of success for this team include mutual respect by all team members, open and honest communication, and an unwavering commitment to patient safety and clinical excellence. The team should have a clear vision, well-known program priorities, as well as a solid understanding of team expectations of all team members. Such clarity allows team members to understand who is accountable for what and the role each plays in the success of the program. Quantifiable outcomes are essential for internal awareness, accountability, and ownership of all team members and are vital for external benchmarking purposes. Sharing of program outcomes with team members can create a great sense of pride and excellence, which should be celebrated by the entire team to further promote the team spirit and organizational pride.

Paramount to the work of this team is a devotion to a culture of patient safety, including a pledge to systematically review near misses and proactively identify potential system errors. Without total team commitment, such efforts can not be fully realized.

A commitment to patient safety requires dedication to ensuring effective team communication. The importance of team communication cannot underscored. The Joint Commission of Accreditation on Healthcare Organizations reported that the leading root cause of sentinel events is communication. Team

communication is uniquely defined by both team members and organizational culture. Ensuring effective communication may be as simple as staying abreast of the latest communication literature and sharing with your team, such as the Institute of Healthcare Improvement's SBAR methodology (Situation – Background – Assessment – Recommendation) intended to build teamwork and strengthening communication among clinicians. However, it is more likely that team communication will need to be an ongoing focus of team development. An assessment of the team's patient safety culture is a great diagnostic to focus team development. The evolution of the electronic medical record (EMR) creates many opportunities to strengthen the team communication and allows for real time integration of all clinicians' input. The design process of the EMR provides the neonatal cardiac team the ability to advocate for the design of a system that enhances the "ready access" of vital information for this unique patient population. It also offers the ability to promote standardization, reduction in variation of practice, and ease of comparative data collection, if designed with such needs in mind.

Many organizations are seeking a designation of nursing excellence as recognized by the Magnet Recognition Program, sponsored by the American Nurse Credentialing Center, a subsidiary of the American Nurses Association. The key characteristics of Magnet organizations are lower nursing turnover and vacancy rates, higher patient/family satisfaction scores, higher nursing employee satisfaction scores and better outcomes of nurse sensitive quality indicators. One of fourteen key organizational attributes that hospitals must be able to validate in order to receive the designation of nursing excellence is strong collaborative relationships, including specific standards related to nurse-physician relations. Studies in the fields of patient safety, patient satisfaction, employee satisfaction, and physician satisfaction all denote the importance and impact of effective collaboration among nurses and physicians.

It is through strong collaborative relationships that the critically ill neonates with cardiac disease will receive the best care and the greatest chance for the future. The dedication of each team member and the contributions of each discipline are strengthened through collegial collaboration.

Conclusion

The start-up project of a neonatal cardiac intensive care program is both exciting and challenging. This endeavor demands a balanced clinical and administrative approach to ensure its success. In his best-selling book Good to Great, author Jim Collins describes characteristics of the very few Fortune 500 companies that have had sustained greatness[16]. One of the most important qualities of such great companies is the willingness to honestly confront the weaknesses of the organization and then implement means to improve while retaining unwavering faith in the company (the so-called "Stockdale Paradox"). As in any business organization, long-term greatness of a neonatal cardiac intensive care service or program can be attained by a relentless effort to improve; this effort, however, needs to be focused and its effects measurable.

Above are some principles and perspectives that jointly lead to essential elements that could serve as underpinnings of a balanced strategy in caring for neonates with heart disease. By using a compendium of clinical experiences, as well as health care administrative principles, caregivers of critically ill neonates with heart disease can attain the highest level of treatment possible.

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MEDICAL NEWS, PRODUCTS AND INFORMATION

Comprehensive Prenatal Test Expands Detection of Genetic Disorders

A new chromosomal test developed at Baylor College of Medicine (BCM) in Houston can now alert pregnant women to an array of fetal disorders otherwise undetectable by conventional tests. This testing was discussed in a commentary and editorial in the December 8, 2005 edition of the journal *Nature*.

"It's the beginning of a sea change in prenatal diagnosis," said Dr. Arthur Beaudet, chair of molecular and human genetics at BCM. "You are going to be able to detect a range of the most severe conditions, and in the future this can be cheaper than current methods hopefully using a very non-invasive approach. The new test can find more disorders and is as at least as fast as previous techniques. It could even lead to more general use of prenatal screening for these disorders," said Beaudet.

The new test uses a gene chip or microarray to analyze various areas of the human genome for abnormal regions that contain too many or too few copies of the genetic material. These gains or losses in DNA can lead to devastating genetic conditions that present serious disabilities for the lives of children born with them.

The microarray or gene chip is like a map that is covered with tiny dots consisting of DNA from known locations on each of the 46 chromosomes. DNA from the patient is labeled one color (for example, red), and DNA from a normal person (control) is labeled another color (in this example, green). The two DNAs are then mixed and added to the microarray. The appropriate part of the genome seeks out the appropriate dot of DNA on the chip and attaches to it. If the DNA in both patient and control is normal, then the two colors of the dye even out and that dot turns yellow. If there is too much DNA (as happens when there are three instead of two copies of a region or an entire chromosome), then the dot is more red because there is more of the patient's DNA. If there is too little, the dot is greener because there is more of the control's DNA and less of the patient's.

Beaudet says the new test can accurately identify a number of chromosomal disorders early in pregnancy that previous screens could not. Among the disorders that this technique will detect are DiGeorge, Williams, Angelman, and Prader-Willi syndromes. It also detects a variety of gains or losses towards the ends (telomeres) of the chromosomes, which are important causes of many developmental disability syndromes.

For women already having amniocentesis or chorionic villus sampling, the new test can be an added analysis on the sample with no added risk. The risk of amniocentesis and chorionic villus sampling to the fetus is even less than has been suggested in the past. The procedure-related risk of amniocentesis is probably only 1:400-500, says Dr. Joe Leigh Simpson, chair of OB/GYN at BCM. Investigators at the University of California at San Francisco have suggested that it is cost-effective to offer traditional amniocentesis to all pregnant women.

"Offering the test to all pregnant women becomes even more attractive using the newer form of prenatal testing because it combines tests for many additional diseases," Beaudet said. Women may increasingly be offered the choice of going straight to amniocentesis or chorionic villus sampling rather than the blood tests and ultrasound tests that are currently used to estimate risks of Down syndrome and decide which women are candidates for amniocentesis.

The comprehensive BCM test is expected to cost approximately $1,900 in addition to the usual costs for amniocentesis and prenatal testing. Procuring the same results using separate, conventional tests would cost around $20,000. For more information,1-800-411-4363.

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