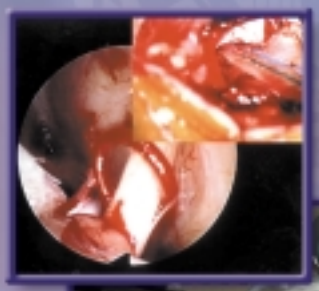


UNIVERSITY of PITTSBURGH

neurosurgery news

Published by the University of Pittsburgh Department of Neurological Surgery • Spring 2001

In this issue:

- Concussions in athletes
- Spine trauma evaluation
- Gamma Knife treatment for trigeminal neuralgia

Cerebral concussion in athletes: evaluation and testing

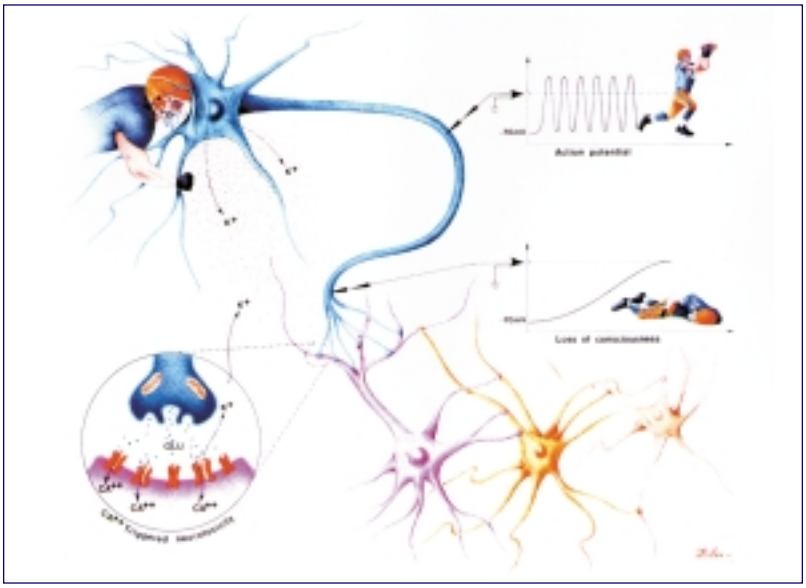
Dr. Maroon
Clinical Professor
of Neurological Surgery

by Joseph C. Maroon, M.D.

The evaluation and management of athletes with cerebral concussion or mild traumatic brain injury (MTBI) is medically challenging and may have profound social and economic consequences for the athlete as well as medical legal implications for the treating physician. They are challenging because there is confusion and disagreement over the definition of a concussion; the timing for an athlete to return to play; the potential danger of returning too soon; the possible cumulative effects of multiple concussions; and the test instruments available to assess post traumatic neuropsychological function in athletes with the postconcussion syndrome.

Physicians often become the final arbiters of whether a gifted athlete with scholarship or professional capabilities is able to continue a sports career or whether the average athlete with a passionate or social need to play a particular sport is able to return to play. Concurrently parental, coach and peer pressure to continue participating in contact sports may be profound. These factors, together with the potential long-term consequences of cerebral concussion, demand that physicians responsible for such decision making understand current guidelines, areas of controversy, and the most current testing instruments for assessing concussed athletes.

For the last two decades, we have managed athletes with MTBI at the high school, college and professional levels. In response to the above problems, we have developed a series of neurocognitive tests to assist in determining when and if an athlete may return to play. These tests are now widely used at the professional level by the National Hockey League (NHL) and the National Football League (NFL) and are being further evaluated at the college and high school level.



Metabolic substrate of cerebral concussion. Changes in the extracellular potassium concentration after concussion. A percussive injury to nerve cells leads to the rapid release of intracellular potassium (upper left). When the extracellular potassium concentration increases beyond the physiological limit of 4 to 5 mmol/L, to levels of 20 to 50 mmol/L and above, inhibition of the action potential and loss of consciousness may occur (lower right). This injury-mediated potassium release can initiate a variety of pathways that lead to secondary brain injury. Depolarization of nerve terminals produced by the elevated extracellular potassium concentration can trigger the release of glutamate, resulting in calcium-mediated neurotoxicity (lower left).

Incidence

In 1999, however, Powell and Barber-Foss reported on their survey of 246 certified athletic trainers, who were asked to report injury and exposure data for high school varsity athletes at 235 U.S. high schools during the academic years of 1995 through 1997. The sports included in the survey were boys= football, wrestling, baseball, and field hockey; girls= volleyball and softball; and boys= and girls= basketball and soccer. They found that MTBI occurred in all of the major sports, but that the incidence for football was markedly reduced from the earlier figure of 200,000 concussions to approximately 40,000 per 1.1 million high school football players.

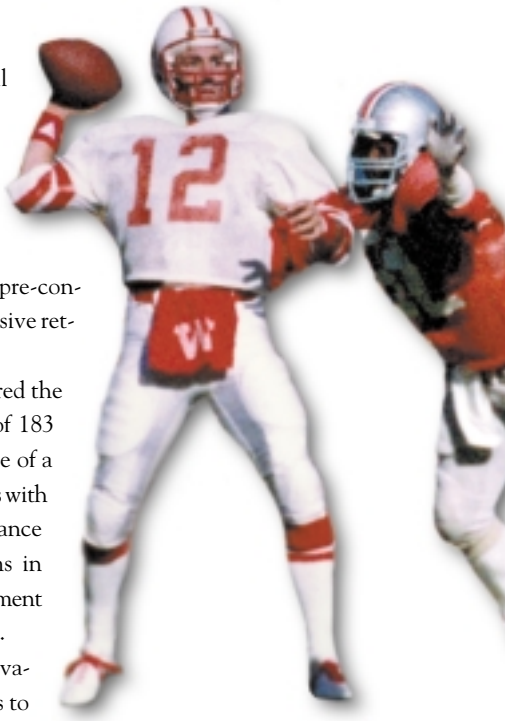
Definition and Guidelines

The word concussion has its origin in the Latin verb *concutere*, "to shake violently." The term "*commotio cerebri*" introduced by Pare in the 16th century has a similar meaning. Although there exists an extensive literature on both the experimental and clinical aspects of cerebral concussion, controversy remains regarding a commonly accepted definition. The term traumatic brain injury (TBI) was introduced into federal law by the Traumatic Brain Injury Act of 1996. Since then, the term cerebral concussion has been used interchangeably with MTBI. A generally agreed upon definition of concussion or MTBI has major implications with respect to the management of an injured athlete, since the definition often determines a management protocol. Commonly used definitions in the past and more recently are those promulgated by Ommaya and Gennarelli, the Head Injury Nomenclature Committee of the Congress of Neurological Surgeons, Robert Cantu, JS Torg and the Sports Medicine Committee of the Colorado Medical Society, which was recently modified by the Quality Standards Sub-committee of the American Academy of Neurology.

In 1986, Cantu evaluated the various definitions, as well as observations on concussions by other neurosurgeons, and modified the definition espoused by the Congress of Neurological Surgeons by incorporating post-traumatic amnesia (PTA) into the definition. In 1991, Kelly worked with the Sports Medicine Committee of the Colorado Medical Society to develop another definition with associated guidelines, subsequently called the Colorado Guidelines for the Management of Cerebral Concussion. The major difference between these and other definitions was that, in their Grade 2 concussion, loss of consciousness was not required. Rather, confusion with amnesia for 15 minutes constituted a Grade 2 concussion. These guidelines further emphasized the importance of the mental status evaluation and promulgated various neurological and exertional tests that should be performed on the sidelines prior to returning to competition.

Building on the Colorado Guidelines, the Quality Standards Sub-Committee of the American Academy of Neurology recently defined cerebral concussion in 1997 as a traumatically induced alteration in mental status that may or may not involve loss of consciousness (see table). Confusion and amnesia are emphasized as the hallmarks of concussion. The confusional episode and amnesia may occur immediately after the blow to the head or several minutes later. This definition obviously emphasizes the poorly appreciated fact that cerebral concussion does, indeed, occur without loss of consciousness and that confusion and amnesia are major considerations in the judgment of whether or not to permit an athlete to return to contact sports participation.

Because of experiences like these and the dearth of scientific data regarding important determinants of concussion severity, many sports medicine practitioners are confused about the various concussion guidelines. In fact, Collins et al. state, it is our opinion that concussion management guidelines have not yet evolved to the extent that they can be used to make reliable return-to-play decisions. The essential element is that athletes should not return to contact sports when significant residual symptoms persist. The various definitions, management guidelines, and tests should be used to supplement the physcian's judgment. Rimel and colleagues at the University of Virginia were among the earliest to emphasize the importance of neuropsychological testing in patients with MTBI. They studied 538 patients who suffered minor head trauma with unconsciousness lasting 20 minutes or less, a Glascow Coma Score (GCS) of 13 to 15, and hospitalization not exceeding 48 hours. Three months after injury, 424 had a high rate of morbidity (79% persistent headaches, 59% memory problems) and subsequent unemployment (34%). In 1969, Yarnell and Lynch were among the first to study memory retention in athletes immediately after concussion during the college football season. They found that, for the first 1-3 minutes after injury, the concussed athletes knew the immediate pre-concussive event, but then developed progressive retrograde amnesia over 3-20 minutes.



In 1996, Macciocchi et al. compared the neurological test scores and symptoms of 183 MTBI-injured college athletes with those of a control group. They concluded that players with head injuries displayed impaired performance and increased postconcussive symptoms in comparison to controls, but that this impairment resolved within five days in most players.

From the above studies and observations, neuropsychological testing appears to provide a sensitive guide to ongoing and possibly cumulative problems following athletic MTBI. As participants at the University of Pittsburgh in Barth's reported study in 1989, we recognized the utility of his contribution to neuropsychological testing in evaluating athletes with MTBI. In 1990, we developed our own testing regimen for professional athletes incorporating many of the principles outlined by Barth in his earlier study.

Neuropsychological Tests – Future Development

Although neuropsychological testing has gained increasing acceptance among sports medicine practitioners, several practical issues have limited its widespread implementation in college and high school athletics. Since evaluation of an entire athletic team is time and labor intensive, many schools are reluctant to embrace these tests due to limited financial resources. Furthermore, prior to 1998, there were no computerized neuropsychological test batteries developed specifically for use with athletes. With the athlete in mind, we recently developed Immediate Post-Athletic Cognitive Testing (ImPACT®). This test battery was designed to evaluate

*(see **Evaluation..** on page 6)*

Grade	Definition	Management Recommendations
1	Transient confusion; no LOC; symptoms resolve in < 15 minutes	May return to play same day if normal sideline assessment at rest and with exertion.
2	Transient confusion; no LOC; symptoms last > 15 min.	Defer contact until one full week symptom free at rest and with exertion.
3	Any LOC either brief or prolonged.	If brief (seconds), defer contact for one asymptomatic week. If prolonged (minutes), defer for 2 asymptomatic weeks minimum

Systematic spine evaluation urged for major trauma victims

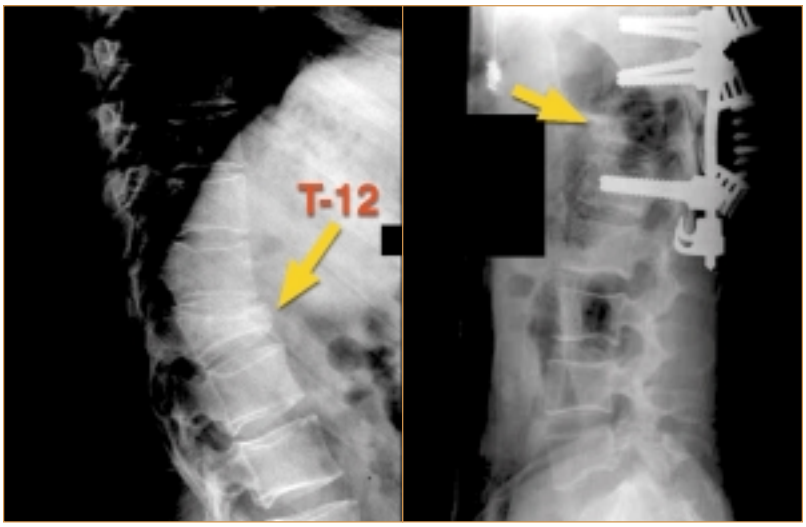
Dr. Marion
Director, Brain Trauma Research Center

by Donald W. Marion, M.D.

Vertebral column injury with or without neurologic deficits must always be considered in a patient with multiple trauma. Five percent of all brain-injured patients have spine injuries, and patients with facial fractures are at particular risk for cervical spine injuries. Most spine injuries occur in the neck (55%) and the remainder are distributed through the thoracic and lumbar spine areas.

Physicians and other medical personnel who care for trauma patients must be constantly aware that excessive manipulation and inadequate mobilization of a patient with a spinal injury can cause additional neurologic damage, or cause a new spinal cord injury that did not previously exist. In one study, at least 5% of patients were found to have had the onset of new neurologic symptoms, or worsening of preexisting ones, prior to reaching a trauma center. While this may have been due to progression of spinal cord edema, in other cases it was clearly the result of failure to provide adequate immobilization of the patient.

Systematic clinical and radiographic evaluation for spine injuries is strongly recommended for all victims of major trauma. In those trauma patients who are neurologically normal, have no pain or tenderness along the spine, are alert and awake, and are not intoxicated, the likelihood of significant vertebral column injury is miniscule and radiographic studies are probably not indicated. For all others the radiologic evaluation is critical. Initially the cervical spine is evaluated with an AP, lateral, and open mouth odontoid view, and with axial CT images for all suspicious areas, or of the lower cervical spine if not clearly visualized on plain films. The thoracic and lumbar spine are evaluated with AP and lateral x-rays. If the patient has neck pain and normal radiographic studies as described above, flexion and extension lateral x-rays are recommended. If the patient has neurologic deficits referable to the spine, an MRI scan is obtained through the appropriate levels. In all cases where abnormalities are found on these radiographic studies, or where there is persistent neurologic deficit referable to the spine, a neurosurgical consult is strongly recommended. Spine protective devices should remain in place until such a consultation is obtained. In the acute setting, these include a semi-rigid cervical collar, such as a Miami-J collar or a Philadelphia collar, as well as a rigid backboard, particularly if the patient is complaining of thoracic or lumbar spine pain. However, trauma patients should remain on a rigid backboard no longer than 2 to 3 hours since serious sacral decubitus ulcers may result with prolonged use.



This 32-year-old man suffered a burst compression fracture of the 12th thoracic vertebrae when he was involved in a motor vehicle accident. Fortunately he did not have significant neurologic deficits as a result. Approximately 70% collapse of the body of T12 is evident with associated angulation deformity. He underwent posterior fusion with stainless steel screws placed into the 10th and 11th thoracic vertebrae and 1st lumbar vertebrae. After attaching metal rods to those screws, we were able to distract the T11 vertebrae away from the L1 vertebrae, thereby restoring nearly 90% of the normal height of the T12 vertebral body. As a result of this internal fixation, the patient was able to be out of bed within 12 hours after surgery and was discharged to home within three days, fully ambulatory.

Recently it has been shown that high doses of steroids can benefit patients who have a spinal cord injury. A very large multicenter trial has found improved outcomes with early, though not late, treatment with high dose methylprednisolone. Another recent finding is that early surgical intervention for internal stabilization of spine fractures can lead to early mobilization of the patient, shorter recovery periods, and a reduced incidence of pulmonary and other complications.

There has been a dramatic improvement in our ability to surgically correct and stabilize spinal column injuries over the past 10 years. At major trauma centers, such as the University of Pittsburgh Medical Center, a full compliment of contemporary instrumentation is available. Our surgeons are skilled at accomplishing even the most complex spine reconstruction and stabilization procedures within hours after patients arrive. Thus, while a patient with a severe burst compression fracture of the thoracolumbar spine may have been placed at bedrest for weeks or months 20 years ago, such patients now undergo internal fixation and stabilization of their injury within hours after

(*see* ***Ability to treat..*** *on page* 6)

Gamma Knife radiosurgery treatment advocated for the facial pain of trigeminal neuralgia

by Douglas Kondziolka, M.D., M.Sc., FRCS(C) and L. Dade Lunsford, M.D., FACS

Trigeminal neuralgia is considered one of the most severe pain disorders that afflicts humans. The cause in most patients is vascular compression of the trigeminal nerve as it exits the brainstem. Other patients may have multiple sclerosis, brain tumor compression or an idiopathic onset. Carbamazepine is the mainstay of medical therapy, but some patients can be helped by phenytoin, lioresal, or high-dose gabapentin. Others cannot tolerate medical therapy, and eventually require surgical intervention. Although often associated with initial pain relief, all surgical procedures have variable but definite rates of recurrence and morbidity. Microvascular decompression is the only procedure that tries to eliminate the cause of the pain. Other options include percutaneous rhizotomies (glycerol, radiofrequency or balloon compression) or radiosurgery. Gamma Knife radiosurgery, a treatment of the nerve proper, has been advocated as a minimally invasive alternative surgical approach, particularly for older patients or those who have recurrent pain after prior surgery.

At present, we have performed radiosurgery in 400 patients at the University of Pittsburgh. High-resolution stereotactic MRI is used to assist targeting of a 4mm diameter radiosurgical volume to the nerve. The treatment is painless. A maximum dose of 80 Gy is often given and patients are discharged from the hospital within 24 hours. Follow-up is obtained by physicians who did not participate in the surgery. Results from the first consecutive 220 patients were recently published (*J Neurosurg* 94:14-20, 2001).

In these 220 patients, the median patient age was 70 years. Although all patients complained of the typical trigeminal neuralgia features of a sharp, lancinating or shooting electric-shock type of pain triggered by a variety of events, sixteen (7.3%) complained of additional features such as a more constant dull, aching or burning pain. Eighty patients (36.4%) had some sensory disturbance (usually paresthesias) preoperatively, and three patients (1.4%) had partial deafferentation pain caused by prior ablative procedures. Prior surgery was performed in 135 patients (61.4%), In these 135 patients, 86 (39.1%) had one, 39 (17.7%) had two, and 10 (4.5%) had three or more procedures prior to radiosurgery. Thus, the majority of patients represented both medical and surgical failures. In the remaining 85 patients (38.6%), radiosurgery was the first surgical procedure performed.

We subdivided clinical results into four categories: excellent, good, fair and poor. Complete pain relief without the use of any medication was defined as an *excellent* outcome. At the initial follow-up assessment, excellent results were obtained in 105 patients (47.7%), and excellent plus good results were found in 139 patients (63.2%). More than 50% pain relief (excellent, good, or fair) was noted in 181 patients (82.3%). At the last follow-up evaluation, 88 patients (40%) had excellent outcomes, 121 patients (55.9%) had excellent plus good outcomes, and 152 were fair or better (69.1%). Thirty patients (13.6%) had recurrence of pain after the initial achievement of pain relief (25 patients after complete relief, five patients after more than 50% relief) between two and 58 months after radiosurgery. Recurrences occurred at a mean of 15.4 months from radiosurgery. These results are not as good as those observed after a *first* microvascular decompression. However, compared with percutaneous surgeries, the pain recurrence rate following radiosurgery seems to be less.

The low incidence of complications is the greatest advantage of stereotactic radiosurgery compared with all other surgeries. Paresthesia or numbness of varying magnitude is observed in 20% to 70% of patients after percutaneous thermorhizotomy, glycerol rhizotomy or balloon nerve compression. In this study, 17 patients (10% at two years) developed increased facial paresthesia and/or facial numbness. Gamma Knife radiosurgery has been established as a safe and effective procedure for patients with medically refractory trigeminal neuralgia, particularly for patients who have failed prior procedures. ■

Dr. Kondziolka
Co-Director, Center for Image-Guided Neurosurgery

Dr. Lunsford
Co-Director, Center for Image-Guided Neurosurgery

'Zap! Surgery' at the Carnegie Science Center

Eight-year-old David Stanick tries out the interactive Gamma Knife display at Pittsburgh's Carnegie Science Center. (See "News & Notes" on page 7).

Evaluation, management of concussions in athletes poses medical challenge

For more info on ImPACT® implementation in high schools and colleges, please contact Dr. Mark Lovell at (412) 432-3681.

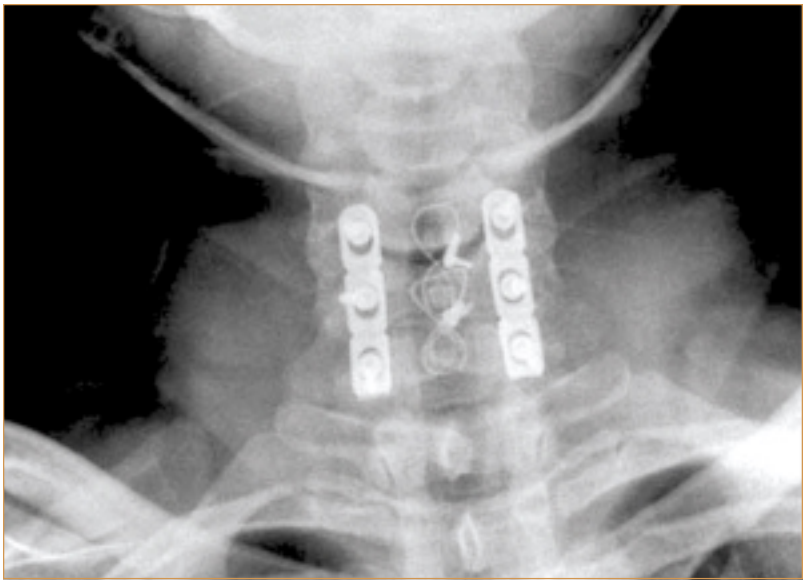
(from page 3)

multiple aspects of neuropsychological function in athletes including attention span, sustained and selective attention, reaction time, and several dimensions of memory. The test battery can be administered via a microcomputer, with a minimum of supervision by a technician. Reaction time is measured to 1,000th of a second across a number of the individual test modules and allows for an assessment of processing speed as the player fatigues. The test battery currently consists of three forms that can easily be expanded to an almost infinite number by randomly varying the stimulus array. This feature was built into the test battery to minimize the practice effects that have limited the usefulness of many paper and pencil procedures. The modules can be administered as a complete test battery or can be chosen separately, and a selection of interstimulus intervals for each module can be easily adjusted.

In addition to these advantages of ImPACT® over traditional neurological testing procedures, the test battery also contains post-concussion scale, which is administered using a microcomputer. All test data are stored in a format that facilitates comparison of post-concussion test performance to baseline performance for each athlete. We have recently completed an initial reliability study at a college located in the midwestern United States (unpublished data). In this study, 82 college students were administered ImPACT® at four different time intervals (one, two, four, and six weeks) to establish the reliability of the test battery over time. The overall average difference in reaction times for the different time intervals was only 0.10 secs (SD=0.54 secs; SEM=0.06 secs), indicating very little variability in non-concussed college students. These data will be extremely valuable in establishing expectations for normal performance in concussed athletes where significantly more variability in performance is expected.

Through such easily administered, low-cost computerized instruments, neurocognitive testing with ImPACT® has now expanded to 200 high schools and 30 colleges. Future data gleaned from our ImPACT® program and others like it may also lead to a reduction in the cumulative effects of concussion when neuropsychological testing is used, and a more precise resolution of issues such as how many concussions are too many. Achieving these goals may help to extend the safety and playing life of the athlete in contact sports. ■

Ability to treat spinal cord injuries has improved dramatically over years



▲ ***A 30-year-old man was involved in a motor vehicle accident and brought to UPMC Presbyterian Hospital with severe neck pain, but neurologically intact. Cervical spine x-rays revealed a subluxation at C6-7 of approximately 50% and this was confirmed on an MRI scan of his cervical spine. The patient underwent a posterior fusion with titanium cables and lateral mass plates screwed into the bodies of C5, C6 and C7, as seen on the above postoperative x-ray.***

(from page 4)

arrival, are walking within a few days, and are able to return home within 3 to 4 days. For those who have severe or complete spinal cord injuries, the spinal cord rehabilitation facilities also have dramatically improved over the past two decades. Currently, there are several very high quality spinal cord rehabilitation programs in southwestern Pennsylvania, lead by the UPMC Rehabilitation Hospital. This hospital recently was awarded a national "model systems grant" from the Public Health Service designating it as one of only 3 or 4 such federally recognized programs in the United States. The program was so designated, in part because of a very strong association with the UPMC School of Health and Rehabilitation Sciences and their groundbreaking work in the development and design of assistive devices and improved wheelchairs for patients with spinal cord injuries. The goal of the spine injury program at the University of Pittsburgh is to provide not only high quality contemporary care during the acute phase, but also to provide such care for the difficult weeks, months, and years following the injury in order to provide optimal outcome following what can be a very devastating change in someone's life. ■

Neurosurgery Staff Commended in Report

In a report commissioned by the Pittsburgh Regional Alliance to identify areas of excellence within the life sciences, several department staff members were cited for their excellent work in neurosurgery. **A. Leland Albright, M.D.** (pediatrics), **Douglas Kondziolka, M.D.** (cellular transplantation), **Donald Marion, M.D.** (head trauma) and **L. Dade Lunsford, M.D.** (Gamma Knife) were credited for helping position Pittsburgh as among the elite in neurological care in the country. The study was funded by the Jewish Healthcare Foundation.

New Clinical Trial Tests Combination of Promising Medications for Malignant Brain Tumors

Malignant gliomas (glioblastomas, anaplastic astrocytomas, and anaplastic oligodendrogliomas) are the most common form of primary brain cancer. First-line treatment usually includes radiation; however, these tumors almost always recur. UPMC clinical researchers are investigating the combination of two chemotherapy medicines, temozolomide and irinotecan, for this problem. Temozolomide was recently approved by the Food and Drug Administration for use in recurrent anaplastic astrocytomas, while irinotecan was recently approved for use in colorectal cancer but has also demonstrated antitumor activity against malignant gliomas. This clinical trial, under the auspices of the North American Brain Tumor Consortium and the National Cancer Institute, will utilize these medications together to establish the effectiveness and side effect profile of this combination. For more information, contact **David Schiff, M.D.** at (412) 692-2600 or **Mark Wargo, R.N.** at (412) 647-5369.

Gamma Knife, Neurosurgery Staff Featured in Carnegie Science Center Exhibit

The high-tech capabilities of the Gamma Knife are showcased in an interactive exhibit running now at Pittsburgh's Carnegie Science Center. *Zap Surgery! Beyond The Cutting Edge* takes a look at the scientific principles of the Gamma Knife and other technologies including cryosurgery, ultrasound, endoscopy and lasers.

The exhibit presents these complex technologies in a clear, understandable manner through videos -- including one featuring our Gamma Knife staff -- virtual reality components, and a 15-passenger motion simulator. Visitors are afforded the opportunity to perform simulated "surgical procedures."

The exhibit runs through January 2, 2002. It then begins a national tour with stops scheduled for Charlotte, Houston, San Jose, Portland and Jersey City.

Recent Grant Awards:

• "Neurocompatability of Tisseel Fibrin Sealant in Primates," **Amin Kassam, M.D.** from Baxter Pharmaceutical Corporation ($250,000). Study to determine whether Tisseel, a human fibrin glue, has detrimental effects when directly applied to the monkey brain and spinal cord.

Media:

• The Xenon CT scan technology work pioneered by **Dr. Howard Yonas, M.D.** was highlighted in the February edition of *Reader's Digest* in the story "Medical Breakthroughs."

• **Ghassan K. Bejjani, M.D.** was interviewed in February by WTAE-TV 4 in Pittsburgh regarding his study of Durasis™, a medical material created to substitute as a covering for the brain or spinal cord following trauma or surgery.

• On March 15, the *Pittsburgh Post-Gazette* featured a front-page story on **Douglas Kondziolka, M.D.** and his neuron cell transplant work.

Awards:

A. Leland Albright, M.D. was the 2000 recepient of the "Order of the Lighthouse Award" presented by Neurological Therapy Specialists. The award is given to individuals showing outstanding contribution, commitment, and dedication in their work and efforts in improving the lives of children and adults with disabilities. Dr. Albright was honored for his pioneering work with spasticity management in children.

Appointments:

Peter Gerszten, M.D. has been appointed the chairman of the outcomes committe of the AANS/CNS Section on Disorders of the Spine and Peripheral Nerves.

New Employees:

Chrisanne Hennicke, physician assistant; **Douglas Clayton**, physician assistant; **Julie Genevro**, nurse coordinator for Michael Horowitz, M.D.; **Judy Montgomery**, project coordinator; **Linda Staub**, charge specialist.

Congratulations:

New baby girl (Danielle Sophia, December 18) to **Mel Field, M.D.** and wife Aileen; new baby girl (Marta Elizabeth, February 14) to **Kevin Stevenson, M.D.** and wife Sara.

Upcoming Events:

• May 16-17: **Regis W. Haid, Jr., M.D.**, associate professor of neurosurgery at Emory University in Atlanta, GA will speak as part of the UPMC Neurological Institute visiting lecture series. Dr. Haid has made significant contributions to the research and development of surgical technologies that have improved the treatment of various spinal disorders. Call (412) 647-3685 for more information.

• June 8: Training course, "Comprehensive Management of Lumbar Spine Disorders," will be held at the Marriott City Center. This course is targeted at physicians interested in comprehensive approaches to degenerative and traumatic diseases of the spine. Call (412) 647-8220 for more information or visit our website at **www.neurosurgery.pitt.edu/spine**. ■

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