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## **Abstracts of American Spinal Injury Association Meeting, 1987**

Held in Boston, Massachusetts, USA, March 1987

*These were kindly collected and abstracted by Dr David F. Apple Jr MD*

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### **Interaction of compression and velocity in determining severity of experimental spinal cord injury**

E. Anderson, PhD

*Biomedical Science Department, General Motors Research Laboratories, Warren, MI 48090, USA.*

Previous experimental spinal cord injury models did not provide the independent control of compression and contact velocity needed to study the amount and velocity of compression interact to define the character and severity of a spinal injury. We therefore developed a controlled spinal cord contusion technique using a pneumatic cylinder to drive an impactor tip against intact spinal cord dura. Anatomic severity of the injury was defined as cross-sectional extent of the hemorrhagic lesion; functional severity was assessed by comparing pre- and post-contusion latency of hindlimb sensory evoked potentials.

We established reproducibly graded injury severity in our model at 3.0m/s contact velocity as a function of amount of compression. Further, cord conduction was significantly impaired for 50% cord compression at velocities from 0.6m/s to 10.0m/s in comparison to both control cords and 25% cord compression. A small, but non-significant increase in latency was observed with increase in contact velocity. Conversely, vascular injury as indicated by extent of hemorrhagic necrosis correlated with contact velocity rather than with the amount of compression. The data demonstrate for the first time a dissociation between subacute hemorrhagic necrosis and loss of neuronal conduction as a function of injury parameters. Although long-term effects of hemorrhagic necrosis on cord structure and conduction remain to be evaluated, the data suggest that delayed loss of neuronal conduction seen clinically may result from moderate cord compression at high contact velocity.

### **The importance of early admission to a system of spinal cord injury care**

D. F. Apple, Jr MD, C. Albright, RN, J. Huckeba, LPN, A. Holt, BA, R. Pollard, MA.  
*Shepherd Spinal Center, 2020 Peachtree Road, NW Atlanta, Georgia 30309, USA.*

The records of all patients with spinal cord injury admitted to the Shepherd Spinal Center between 1975 and 1986 were analyzed. The information on 440 quadriplegics and 400 paraplegics was available. There were 63 patients with high quadriplegia (C1 to C4), 396 low quads, and 381 paraplegics. Of these 445 were complete with 395 being incomplete.

Analysis of the data seemed to indicate that early admission to a categorical spinal cord center did shorten the patients total care time by the number of days it took the patient to get into the system. Regression analysis implied that the savings was two thirds to three quarters of a day for each day the patient spent out of system. The authors felt that no matter what complications the patient had on admission, the unit functioned well enough to achieve rehabilitation in a similar amount of time. Looking at complications, the presence of decubitus ulcers on admission appears to be the main reason for prolonging the stay. Pneumonia was the next most significant complication to add to the length

of stay. Surgery as a means of management did not improve the length of stay in those patients managed by the center physicians. Even when non-operative management was selected, the patient was generally up with appropriate bracing within a short period of time. It was not possible to show that a surgical approach improved the neurological outcome using the motor index score. The authors felt that a patient does have an advantage if admitted early in the critical care time of somewhere between 14 and 21 days post injury. The number of all complications increased in those patients admitted beyond that period of time whereas part of this time frame, the number of pneumonia and decubitus complications were decreased.

### **Cervical injuries in football players**

R. G. Watkins, MD, W. H. Dillin, MD, J. E. Tibone, MD, C. L. Shields, MD, and R. K. Kerlan, MD

*501 East Hardy Street, Suite 200, Inglewood, California 90301, USA.*

The authors reviewed 153 cases of sports injuries over a 3 year period. Forty percent of these injuries were obtained while playing football. Multiple problems were represented and although there was transitory paraplegia in several cases, there was no permanent neurological deficit. Classification of mild, moderate, or high risk categories were developed regarding recommendations for continued football play. The predicted risk was categorized as to risk the permanent damage and the risk of continued symptoms. Three additional recommendations made based on this review were:

1. Shoulder pad modification which produced a total resolution of burner and stingers in 90% of cases.
2. Modification of X-ray techniques which produced full visualization of the entire cervical spine in the locker room setting.
3. A system of evaluation of cervical injury during the contest which has been effective in preventing progressive injury.

### **Analysis of recreational off-road vehicle accidents resulting in spinal cord injury**

F. M. Maynard, MD

*University of Michigan Medical Center, Department of Physical Medicine and Rehabilitation, 1500 East Medical Center Drive, Room UM1D202B-0042, Ann Arbor, Michigan 48109, USA.*

Twelve cases of spinal cord injury resulting from recreational off-road vehicle (ORV) accidents seen during a 3 year period at a spinal cord injury centre were analyzed using structured interviews and record reviews. Seven accidents involved three-wheeled all-terrain vehicles (ATVs), 1 involved a four-wheeled ATV and 4 involved two-wheeled trailbikes. Analysis of accident victim characteristics showed all age groups are at risk and most victims were young adult male vehicle drivers with experience and wearing helmets. The levels of spine injury were cervical (3), thoracic (3), and thoracolumbar (6). Accident hazard patterns were categorized as loss of control (6), tipover (4), and hidden obstacle (2). Contributing causative factors to the accident occurrence were poor driver judgement (7) and vehicle instability (8). Speeding was the most frequent primary cause of ORV accidents. Vehicle and driver performance characteristics are discussed as they relate to risk of accident occurrence. The frequency of ORV accidents as an etiology of traumatic SCI at this centre was 8% as compared to 8% for diving accidents and 11% for motorcycle accidents. In view of the high risk of severe injury, widespread public education about ORV accident prevention is recommended.

### **Spinal cord injuries and a mandatory seat belt law**

J. Kuric, RN, BSN, CCRN, C. Harrison, BS

*Detroit Receiving Hospital, Rehabilitation Institute, Detroit, Michigan, USA.*

On July 1, 1985, a mandatory seat belt law went into effect in the state of Michigan. The Southeastern Michigan Spinal Cord Injury System collected and compared data on the number of motor vehicle accident related spinal cord injuries treated in the system during the year previous to the law and the first year the law was in effect.

During year 1, there were 15 spinal cord injuries as a result of motor vehicle accidents out of a total of 78 cases treated in the system, indicating a 19% occurrence rate. During the first post law year, 15 spinal cord injuries occurred as a result of motor vehicle accidents out of a total of 88 patients for an occurrence rate of 17%, a 2% decrease. The expected significant decrease in the number of motor vehicle accident related spinal cord injuries was not seen.

This was felt to be related in part to the low compliance rate with the mandatory law. In the year prior to enactment of the mandatory seat belt law, 43% of Michigan drivers utilized seat belts. During the first two months of the law, compliance rose to 58%. However, by the third month, it dropped back to 43% and has remained at that level since.

### **Spinal cord injury: a group-oriented approach to treatment**

E. Kaminsky, OTR/L, D. Petrillo, OTR/L

*Magee Rehabilitation Hospital, Six Franklin Plaza, Philadelphia, Pennsylvania 19102, USA.*

A group-oriented approach to Occupational Therapy treatments of SCI patients at Magee Rehabilitation Hospital is described. Groups include a Community Living Skills Group, an Aerobics Group, Functional Mobility Groups (level 1 and level 2) and an Upper Extremity Coordination Group. A protocol for each group establishes criteria for admission and discharge, the referral process and guidelines for documentation. The responsibility of primary therapists for referral, goal identification and progress documentation is described. The pros and cons of the group-oriented approach based on feedback from patients and staff are discussed. Reaction has been primarily positive.

### **Indirect decompression of the spinal canal in thoracolumbar spine**

A. M. Levine, MD, C. C. Edwards, F. Gellad

*University of Maryland Hospital, 22 South Greene Street, Baltimore, Maryland 21201, USA.*

Fifty consecutive patients with thoracolumbar fractures between T3 and L3 were admitted to the University of Maryland Hospital and Maryland Institute for Emergency Medical Services and underwent posterior reduction and stabilization using spinal rod sleeves, straight Harrington rods and anatomic hooks. Thirty-four patients underwent surgery within 48 hours of injury, 8 within 2 to 14 days and 8 after 14 days. All patients underwent pre and postoperative CAT scans and interoperative myelograms. Canal area and midsagittal diameters were calculated directly on the CAT scanner at the level of injury as well as the normal segment above and below.

Preoperative canal area at the level of injury averaged 52% of normal for all patients. Following posterior reduction and stabilization, intra-operative myelography demonstrated dye passage in all cases. For cases done within 48 hours of injury, postoperative CAT scan showed improvement in canal area to 83% of normal. In contrast, in four cases done more than 14 days from the time of injury, no indirect decompression of fragments was accomplished. Since the majority of thoracolumbar fractures are caused

by axial compression and some flexion, posterior longitudinal fragment should remain intact. By obtaining an anatomic reduction with this with restoration of normal vertebral height, posterior fragments are indirectly reduced by the posterior longitudinal ligament. The authors concluded that this posterior method can, in addition to providing anatomic alignment and rigid fixation, provide significant decompression for thoracolumbar fractures treated within several days of injury.

#### **The ascending cord syndrome – The effect of decompression**

I. G. Yablon, MD, J. Ordia, MD, E. Spatz, MD, J. Reed, MD, R. Mortara, MD, M. Freed, MD, L. Curtis, MD, S. Bergman, MD

*720 Harrison Avenue, Suite 808, Boston, Massachusetts 02118, USA.*

Ascending cord syndrome which may occur from 24 hours to 4 weeks following injury is a poorly understood clinical condition in which the presenting neurologic deficit following trauma of the spinal cord progresses to a higher level. The two most common hypotheses have been vascular and compressive. Late ascending paralysis is understood to be one of the sequelae of spinal cyst. Recently, magnetic resonance imaging has demonstrated that ascending paralysis may occur without cyst formation and such condition has been termed myelomalacia. The authors cases demonstrated progressive loss of function from 24 hours up to 4 weeks following injury. Typically the patient was stable for the first few days and then showed a gradual loss of function in one or more levels. Myelography and CT scans may be normal or may show diffuse cord swelling. Once the ascending loss manifests itself, decompression, either by laminectomy or anterior corpectomy does not improve the picture significantly. Ten of the authors' 54 patients (5.4%) who did not have surgery ascended one to four levels. Four of the 80 patients who had surgery (5%) ascended one to four levels. These differences were significant for p value less and 0.05. The authors felt that a review of the literature strongly suggested early decompression of the spinal cord with anatomical reduction of the vertebral column affords the injured cord the best opportunity to recover from swelling and minimizes the ischemic effects of injury.

The authors felt that their findings were preliminary, but nevertheless felt from this comparatively well controlled study population, the only major factor influencing neurologic recovery was the amount of neurologic injury as was reflected in the initial deficit. For incomplete paraplegics treated with full correction of their post-traumatic deformity, neither time to surgery within 12 hours nor restoration of more than two-thirds of the canal diameter made any noticeable difference in the degree of neurologic recovery.

#### **Neurocognitive assessment in acute spinal cord injury: Incidence and Etiologic factors**

G. Davidoff, MD, MS, P. Thomas, PhD, S. Berent, PhD, M. Dijkers, PhD, D. Klisz, PhD

*Departments of Physical Medicine and Rehabilitation and Psychiatry, University of Michigan Medical Center, Ann Arbor, and the Southeastern Michigan Spinal Cord Injury System, Rehabilitation Institute, Detroit, USA.*

This report presents the first year's findings in a prospective collaborative study of acute spinal cord injured patients admitted to the University of Michigan Center or the Southeastern Michigan Spinal Cord Injury System within 45 days of injury. Fifty patients were administered a predominantly motor-free neuropsychological battery an average of 75 days post injury. Impaired cognitive performance was noted in 60% of the patients in at least one of the following tests:

Rey Auditory and Verbal Test (RAVLT);  
Halstead Category Test, booklet form (HCT);

Logical Memory Subtest, Wechsler Memory Scale (LM);  
 Visual Reproduction Subtest, Wechsler Memory Scale (LM);  
 Associated Learning Subtest, Wechsler Memory Scale (AL).

In addition, the vocabulary subtest of the Wechsler Adult Intelligence Scale-Revised (VOCAB) was evaluated as an index of premorbid intellectual functioning and the Zung Depression Scale was given to test the hypothesis that test performance would correlate with depressed mood. Results of multiple linear regression analysis showed 25–35% of the variance in the performance of three tests (HCL, VR, AI-30 Minute Recall) could be explained on the basis of increasing age. Ten percent of the variance in the performance of AL could be explained on the basis of VOCAB performance, an indirect measure of premorbid intelligence. There was no correlation between neuropsychological test performance and the Zung Depression Scale scores. Patients with closed head injury had a superior performance on LM.

#### **A comparative study of five low pressure mattresses**

G. W. Wharton, MD, J. C. Milani, MD, L. S. Dean, RN, MSN

*Metroplex Regional Spinal Cord Injury Program, Dallas Rehabilitation Institute, 9713 Harry Hines Boulevard, Dallas, Texas 75220, USA.*

Seventeen healthy volunteers, 3 men and 14 women were tested lying both supine and side lying on 5 products:

1. The Biogard Foam Mattress.
2. Zimmer Foam Mattress.
3. Geo-Matt Mattress.
4. Gaymar Soft-Care Mattress.
5. Kin Air Bed.

Pressure under bony prominences at the occiput, sacrum, and trochanters were measured with the Texas Interface Pressure Evaluator. Using a variety of statistical analysis techniques, the Kin Air Mattress had significantly ( $p < 0.05$ ) lower average pressure relief characteristics than any of the other mattress types. Average pressures recorded in the foam products were very similar with the Geo-Matt being overall slightly lower. The Gaymar Soft-Care Air Mattress was similar in pressure readings to the foam products. The Kin Air Bed when compared to the potential cost for treating a pressure sore justifies the expense for specialized beds and mattresses.

#### **Demographic analysis of 552 patients with acute spinal cord injury in Ontario, Canada, from 1948 to 1981**

C. H. Tator, MD, PhD, FRCS, E. G. Duncan, BSc, MB, ChB, FRCS, V. E. Edmonds, RN, L, I. Lapczak, BSc, D. F. Andrews, PhD

*Toronto Western Hospital, Suite 4034 Edith Cavell Wing, 399 Bathurst Street, Toronto, Ontario, M5T 2S8 Canada.*

The authors aims were to analyze demographic details of the first 201 patients with acute cord injury admitted to an Acute Spinal Cord Injury Unit, established in 1974 at Sunnybrook Medical Centre, Toronto, (the 'new' group), and to compare this group with a group of 351 patients with acute cord injury treated in Sunnybrook and Toronto General Hospitals prior to the establishment of the Unit (the 'old' group). Ten admission variables were recorded: sex, age, presence of pre-existing spinal abnormalities, type of accident causing the injury, distance from the accident site to a study hospital, interval from injury to admission to a study hospital, level and type of spinal column injury as assessed by radiography, severity of cord injury (using a numerical spinal cord injury score), and severity of combined spinal and non-spinal injuries, recorded as an anatomical injury

severity score. Three outcome parameters were examined, mortality rate, length of first hospitalization and neurological recovery. Results revealed that there was no statistically significant difference between the two groups for sex and age of the patients, the incidence of pre-existing spinal abnormalities and the frequency of injury to the cervical, thoracic and thoracolumbar levels. However, the new group had a higher percentage of injuries due to motor vehicle and sports recreational accidents, and a lower percentage of work-related accidents. The new group travelled a shorter distance to reach the Unit and was admitted sooner after injury. The median delay to admission decreased from 13 to 5 hours and the mode from 24 to 3 hours for the old and new groups, respectively. The proportion of complete cord injuries decreased from 65% in the old group to 46% in the new group. Examination of the type of bony injury to the vertebral column revealed that there were fewer patients with normal radiographs and compression fractures and more with burst fractures in the new group as compared to the old. Combined spinal and non-spinal injuries, as assessed by the injury severity score, were less severe in the new group than the old, due to the reduced severity of the spinal cord injuries. With respect to outcome, the overall mortality rate decreased from 20% to 9% and the length of the hospitalization was halved from 99 days to 50 days for the old and new groups respectively. Neurologic recovery, as analyzed by a 17-point numerical scale, was improved in the new group. The authors concluded that the establishment of an Acute Spinal Cord Injury Unit resulted in more rapid admission of patients following spinal cord trauma and contributed to improved outcome including reduced mortality, reduced length of first hospitalization, and enhanced neurologic recovery.

### **Spinal cord injury in three regions in the United States**

S. R. Garfin, MD, L. F. Marshall, MD, H. M. Eisenberg, MD, D. Kopaniky, MD, K. Tabaddor, MD

*Division of Orthopaedic Surgery, UCSD Medical Center, 225 Dickinson Street, San Diego, California 92103, USA.*

Three hundred and seventy one acute spinal cord injury patients admitted to five regional trauma centres in the United States between 1982 and 1983 were evaluated. The object was to evaluate the course of the spinal cord injury acutely, and to evaluate care systems.

Motor vehicular accidents were the most common mechanism of injury (46%) followed by falls and gunshot wounds. Mortality was 6.4% and did not differ significantly by mechanism of injury. Twenty four percent had blood levels consistent with alcohol intoxication and 2.4% had toxicological evidence of other substance abuse. The majority of the patients with cervical injuries had incomplete lesions, while 69% of the thoracic injuries were considered complete. Thirty three percent of the cervical spine injured patients were transferred from the field to the hospital with only a soft collar or no cervical immobilization. This was considered inadequate immobilization for acute transportation.

Plain radiographs were obtained for all patients. Of the 151 patients who underwent spinal surgery, only 45 had CT scans preoperatively. In those who had a CT scan, 13 had the diagnosis changed by the CT scan result and in 7 of those 13 patients, the surgery was altered from that originally planned. This data suggests that CT scans are extremely important and useful in the evaluation and establishment of treatment plans for spinal cord injured patients. Sixty seven percent of those with complete injuries and 55% of those with incomplete injuries were treated without surgery. Rehabilitation was considered less than optimal in 18%. The main reason was, however, an inability to get the patient into a rehabilitation facility rather than from deficiencies in the treatment plans themselves.

This suggests that there exists a lack of consensus regarding spinal cord injury care and evaluation. Additionally, improvement in prehospital and rehabilitation service in the United States is needed.

**The development and utilization of a patient acuity classification system in a rehabilitation setting**

D. Disher, RN, BSN, T. Dockery, RN, BS, S. Finnigan, RNMS, K. Hulsey, AD, M. T. Johnson, RN, MSN, C. Perkins, RN, BSN, J. Schirmer, RN, BSN  
*Shepherd Spinal Center, 2020 Peachtree Road, NW Atlanta, Georgia 30309, USA.*

The authors describe the development of a patient acuity classification system at the Shepherd Spinal Center in Atlanta, Georgia. Seven day random work sampling with audits of 90 charts were completed. This allowed the generation of acuity lists for patients both in the special care setting and within the full rehabilitation programme. Nursing staff records the frequency of various test elements in order to project the nursing care requirements on a daily basis. Staffing patterns are adjusted to meet these required needs, thereby maintaining quality care and cost effectiveness. The authors note that medically unstable patients are not well presented in this patient acuity classification system at their centre.

**SCI care system evolution and the associated effects on acute medical complications and length of stay**

R. H. Adkings, PhD, R. L. Waters, MD, M. H. Weiss, MD, D. E. Garland, MD, K. Kendell, LVN  
*PO Box 3715, Downey, California 90242, USA.*

The authors emphasized the importance of systemized care for spinal cord injured individuals by illustrating the development of a system of care in conjunction with changes and complications rates and required duration of hospitalization. The data concerning individuals injured as of January 1980 and through calendar year 1985 were examined. During this time, over 700 consecutive spinal cord injured cases were reviewed. The results indicated that there was a significant reduction of pressure sores, urinary tract infections and pulmonary complication rates over time as the care system matured. There were also a difference in the lengths of stay and complication rates comparing those patients who entered the system within 24 hours versus those who did not. The authors concluded that important improvements in the care of spinal cord injured patients accrue to the establishment and further development of a care system and generally provide strong evidence in favour of systemized care for the spinal cord injured.

**Functional outcome following spinal cord injury: a comparison of specialized spinal cord injury center vs. General hospital acute care**

A. W. Heinemann, PhD, G. M. Yarkony, MD, E. J. Roth, MD, L. Lovell, BS, B. Hamilton, MD, PhD, P. R. Meyer, Jr, MD, J. T. Brown, MD  
*Rehabilitation Institute of Chicago, 345 East Superior Street, Chicago, Illinois 60611, USA.*

Patients with acute SCI who were treated initially in a specialized SCI care unit (88 centre patients) were compared with patients who were managed initially at general hospitals (89 non-centre). All patients were admitted to the Rehabilitation Institute of Chicago and received the same programme. Centre and non-centre patient groups did not differ on the basis of age, or on the basis of distribution according to sex, level or completeness of SCI, presence of deep vein thrombosis, tracheostomy, or spine instability at rehabilitation admission. Mean number of pressure sores, long bone fractures, surgical procedures, or internal injuries prior to admission were not significantly different. Mean duration from injury to rehabilitation was significantly less for centre patients (mean = 29.6 days) than for non-centre patients (mean = 68.1 days).

Mean Barthel Scores were similar for the two groups at admission; but, analysis of covariance showed that centre patients were discharged with significantly greater func-

tional abilities than were non-centre patients. Patients with 1) incomplete lesions, 2) paraplegia, 3) greater admission functional abilities, and 4) shorter duration from injury to rehabilitation had greater functional abilities at discharge. A significant interaction between injury level and injury completeness was found such that patients with complete quadriplegia were discharged with significantly lower functional abilities than patients in the three other groups. The finding that functional improvements could be made to higher levels and at more efficient rates by patients managed initially in a specialized centre supports the practice of managing acute SCI patients in designated SCI centres.

**Anterior decompression of burst fractures with spinal I-plate fixation: a clinical and experimental study**

H. A. Yuan, MD, K. A. Mann, MS, B. E. Fredrickson, MD, J. P. Lubicky, MD, S. A. Albanese, MD

*Department of Orthopedic Surgery, SUNY HSC-Syracuse, 750 East Adams Street, Syracuse, New York 13210, USA.*

The anterior route for treating fractures of the thoracolumbar spine has regained popularity because it provides direct visualization and treatment of the compromised region. Additionally, the short level of fusion consisting of two motion segments also reduces the risk of adjacent motion segment disorders when compared to the traditional five to seven level posterior fusions. The authors developed an I-plate system for stabilization of single level anterior intervertebral fusions of the thoracolumbar area. The device was designed to provide immediate postoperative stability and enhance fusion mass consolidation, promote early patient ambulation and prevent late settling, instability, or kyphotic deformity.

In order to determine the efficacy of the I-plate system, two separate in vitro biomechanical investigations were performed. The first study compared the I-plate to other available anterior fixation systems and their ability to stabilize the decompressed and grafted spine. The second study was performed to determine the effectiveness of the I-plate system for the treatment of vertebral body fracture, combined with various degrees of posterior disruption. The I-plate system improves stability significantly in forward flexion and in left to right lateral flexion. In those loading modes, the spine is more rigid than the intact spine until sectioning of several posterior elements. In extension and both axial rotations, the I-plate does not improve stability nor become much more flexible until sectioning of most of the posterior elements.

The authors concluded that the anterior spinal fixation as with the I-plate system can return stability to that of the intact spine if all posterior elements are intact. Large increase in stiffness can only be expected in flexion and left and right lateral bend. Therefore, additional external stabilization should be used to control axial rotation and extension. If a burst fracture is accompanied by extensive posterior element disruption, then additional posterior internal fixation should be considered.

**Short range, stable-angled dorsal spinal stabilization with simultaneous ventral approach**

P. Kluger, MD, H. J. Herner, MD

*Werner-Wicker-Klinik, Im Kreuzfeld, 3590 Bad Wildungen, West Germany.*

The author stated that in old traumatic deformities and ventrally situated tumors, an exclusive dorsal approach is not adequate and advocated the short stabilization by means of a stable angle bridging over instrumentation such as DICK's Fixateur Interne of Kluger's Spinal Fixation System. The authors felt that these instruments in a simultaneous ventral and dorsal approach simplified the ventral osteotomy and reduction. The authors applied these instruments in 20 cases of traumatic deformities and instabilities with appropriate symptoms and in four cases of tumour. The authors concluded that in no cases where the



ventral approach to the thoracic and lumbar spine is unavoidable, the simultaneous dorsal instrumentation proves advantageous to better reduction, early mobilization, the fact that the fusion only takes place in the affected segments.

### **Single stage anterior decompression and stabilization for burst fractures of the Thoracolumbar spine**

J. P. Kostuik, MD, FRCS(C)

*Toronto General Hospital, 200 Elizabeth Street, Eaton North 1-122, Toronto, Ontario, Canada.*

Seventy patients with thoracolumbar fractures were reviewed retrospectively. All of these patients underwent vertebral body excision, dural decompression and strut grafting through an anterior approach. Neurologic deficit was present in 58. A complete deficit was found in four and incomplete or cauda equina lesions were seen in 54. Correction of the deformity and stability were obtained by anterior Kostuik-Harrington instrumentation along with iliac bone graft, used in 70 procedures. Posterior instrumentation was added in two cases. Complications included pseudarthrosis in three and graft collapse in five, and in one patient infection. There was no increase in neural damage. An average of 1.6 grades neurologic recovery occurred in 100% of cases with incomplete neurological deficit. The four complete paraplegics remained so. Thirty-six partial paraparetics recovered completely. The author concluded that single stage anterior decompression and stabilization of thoracolumbar fractures is safe and effective with a low incidence of complications, and is indicated in cases of incomplete cord or cauda equina deficit with continued compression of the spinal canal by bone, and in cases of progressive or painful post-traumatic deformity with or without neural deficit who are seen late.

### **Undetected post-traumatic instability of the thoracolumbar spine**

J. S. Keene, MD, E. G. Lash, MD, T. F. Kling, Jr, MD

*University of Wisconsin Clinical Science Center, 600 Highland Avenue, Madison, Wisconsin 53792, USA.*

The authors reviewed 105 consecutive patients who had operative stabilization of thoracolumbar fractures. The review revealed that seven patients with flexion-distraction injuries had surgery for symptomatic, chronic vertebral instability. The level of injury was thoracolumbar (T11-L1) in three, and lumbar (L2-L5) in four. All of these patients had 'stable injuries' that were treated non-operatively, and were expected to heal. All seven had persistent pain after non-operative treatment and a positive spine instability test at the level of their injury.

The results of surgery in these seven patients were compared with nine other patients who had surgery for chronic vertebral instability (7 compression fractures, 1 burst fracture, and 1 fracture-dislocation). The seven patients with flexion-distraction injuries had good results following posterior stabilization and fusion of their spine. Five of the seven patients with compression fractures had poor pain relief after having similar procedures. The burst fracture and fracture-dislocation patients were successfully treated with posterior stabilization, and anterior combined with posterior stabilization, respectively.

The authors concluded that: (1) chronic instability (often unrecognized) does occur with flexion-distraction injuries and it can be successfully treated with posterior stabilization and fusion of the involved vertebrae; (2) late posterior stabilization of compression fractures has a high percentage of poor results; (3) internal fixation of chronically unstable fractures is associated with better results than posterior fusion alone; and (4) all types of spinal injuries may result in symptomatic, chronic instability.

### **Stabilization of the lower thoracic and lumbar spine with the internal spinal skeletal fixation system**

M. Abei, MD, J. S. Thalgott, MD

*Department of Orthopedic Surgery, University of Berne, Inselspital, 300 Berne, Switzerland.*

Thirty patients with thoracolumbar burst fractures were treated by the internal spinal skeletal fixator system at the University of Berne, Department of Orthopedics. All patients in the study had a minimum follow up of 12 months. The patients were evaluated on clinical parameters of residual pain, neurologic changes and deformity. The location of the operative managed fractures ranged from T8 to L3, with the majority of them being at T12-L1. The average spinal canal narrowing preoperatively was 56% with a range of 10 to 100%. Sixteen of the patients were Frankel E, 10 were Frankel D, 2 were Frankel C, 1 Frankel B, and 1 Frankel A. The average preoperative kyphosis measured by the Cobb method was 16°. At 12 months follow up there was a minimal loss of reduction to 6.3° of kyphosis. The average anterior body height of the involved segment was 57% preoperatively and postoperatively, this increased to 92%. Preoperative posterior vertebral body height was 88% and this was reconstituted to an average of 103% postoperatively. The authors evaluated the canal anatomy restoration by the presence of free flow of myelography dye past the fracture site. Free flow was obtained in all but one case, and that one was done 3 weeks post injury. Complications were two loosening of the screw in the series, one of which required reinstrumentation and anterior decompression. Postoperatively, the patients were immobilized in a light external orthosis for 8 weeks. The authors concluded that the internal spinal skeletal fixation of Dick's appears to provide rigid spinal fixation, multiplanar reduction capabilities and limited segmental fixation. It also appeared to have the ability to efficiently decompress the retropulsed middle column in burst fractures.

### **Spinal tumours: surgical treatment and outcome**

G. W. Wharton, MD, J. C. Milani, MD

*Metroplex Regional Spinal Cord Injury Program, Dallas Rehabilitation Institute, 9713 Harry Hines Boulevard, Dallas, Texas 75220, USA.*

With improved longevity being experienced in patients with primary malignancies, physicians dealing with spinal disease will have increasing exposure to the problems associated with metastatic spread to the spinal column. The most common tumours to metastasize to bone are lung, breast, prostate, kidney and thyroid. Primary spinal bone tumours are significantly less common than metastatic lesions. The authors reviewed 13 patients who underwent 16 procedures referable to primary metastatic tumours of the spine. Metastatic breakdown was breast 3, uterus 1, prostate 1, colon 1, lung 3, and renal 2. The distribution of tumours were cervical 4, thoracic 8, and lumbar 1. Thirteen patients had anterior approaches and 2 had posterior approaches. Five patients received preoperative chemotherapy and three received chemotherapy postoperatively. Eight patients received radiation before surgery and 7 after surgery.

Six patients expired during a range of 3 days to 6 months from the time of surgery. Two patients are alive 24 months postoperatively, although one has a newly diagnosed additional metastasis.

The authors concluded that the patients in this study group had incomplete spinal cord injury which was expected to become irreversible rapidly if allowed to persist. Significant neural recovery was routinely seen when rapid decompression and stabilization was undertaken. Six patients have done extremely well for periods of up to 24 months after surgery. It was felt that their quality of life and longevity was positively affected by the surgical procedures. Complications were uncommon and were felt to be largely preventable with increased experience with spinal tumours.

**Facet injuries in the cervical spine**

A. M. Levine, MD, J. B. White, C. C. Edwards

*University of Maryland Hospital, 22 South Greene Street, Baltimore, Maryland 21201, USA.*

Between 1979 and 1985, 55% injuries in 54 patients presented to the Orthopaedic Service at the University of Maryland Hospital and Maryland Institute for Emergency Medical Services. Of these, 33 patients had unilateral facet injuries and 21 and 22 bilateral facet injuries. The majority of the injuries occurred at C4-5 (12), C5-6 (17), and C6-7 (18).

Of the unilateral facet injuries, 10 were dislocations and 22 were fractures. The reduction of the facet dislocation could be achieved by closed manipulation (5 patients) who were felt to be stable and could be held by external mobilization because the bony buttress of the facet remained intact. When an adequate closed reduction could not be achieved (5 patients) an open reduction of the facet was done preserving the intact facet and a one level interspinous or oblique wiring and fusion was done. Unilateral facet fracture (22 patients) is a rotational injury with fracture of the superior facet and loss of bony buttress effect. These injuries may be reduced by traction, but the rotational control is not maintained in the halo vest or by interspinous wiring causing recurrence of the deformity in 5 patients. Oblique wire was used to control rotation with satisfactory maintenance of correction in 18 patients.

The bilateral facet injuries were either bilateral facet dislocations in 14, bilateral facet fractures in 2, or fracture on one side and dislocation on the other at 6. As a result of the flexion force causing complete ligamentous disruption, bilateral facet dislocations are unstable. Closed reduction can often be obtained and redislocation does not often recur because of the intact bony buttress of the facets. However, treatment in a halo vest may result in a residual kyphotic deformity. A one level interspinous wiring and fusion can achieve and maintain anatomic alignment.

The authors felt that bilateral facet fractures are infrequent but they did exhibit bidirectional rotational instability which necessitated oblique wiring on both sides to achieve rotational control as was done in two patients.

The authors concluded that with both unilateral and bilateral facet dislocations of the cervical spine, the nature of the instability is related to whether ligamentous disruption or fracture of the bony buttress of the facet has occurred. Appreciation of the nature of the instabilities in cervical facet fractures allows a precise understanding and application of treatment alternatives.

**Initial clinical experience with a new halo vest, and comparison to 'standard' halo vests**

M. Krag, MD, B. Beynon, K. Gill, A. Levine, S. Weinstein

*Orthopaedics & Rehabilitation, University of Vermont, Burlington, Vermont 05405, USA.*

The use of traditional halo vests is associated with a series of potential problems: (1) loss of fracture/dislocation reduction; (2) pin loosening; (3) scapular pressure sores in patients with quadriplegia; and (4) difficulty in washing, dressing, and other activities of daily living. The authors attempted to improve the halo design with the major characteristic of the halo vest being (1) maximum contact with torso sites which best control thoracic motion (sternum, intrascapular region, ribs along the midaxillary line), (2) no contact with torso sites which can produce undesired cervical forces, (3) no scapular contact and thus no pressure sores from vest, (4) torso contact by four separate pads for easy washing and dressing, and (5) easy access to face and ear for personal hygiene and telephone use.

The new vest was tried at four separate centres. The prospective study involved standardized clinical x-ray reviews at regular intervals (0, 6 weeks, 3 months, and 12 months). Just before removal of the halo vest (usually at 3 months) comparative testing was done on the new vest and then a standard vest. The testing included lateral x-rays, supine and

sitting to measure cervical motion and subject questionnaire rating the ease of performing various activities of daily living.

### **Ventilatory muscle training (VMT) with 6 chronic ventilator dependent quadriplegic men**

S. Hornstein, BSc (PT), J. R. Ledsoe, MD

*Neil Squire Foundation, 451-810 West Broadway, Vancouver, BC V5Z 4C9, Canada.*

The authors describe a ventilatory muscle training programme with 6 chronic ventilator dependent quadriplegic men. SCI levels varied from C1 to C3 complete quadriplegia in 5 men, C2 incomplete for the sixth subject.

The objectives were to (1) develop a safe, ongoing VMT programme using the technique of inspiratory resisted breathing; and (2) to increase their spontaneous breathing time so as to provide them with a 'built-in' emergency system to guard against respiratory failure from disconnection.

Baseline assessments included a respiratory history pre and post injury and pulmonary function studies. Ongoing monitoring during resisted breathing included end-expiratory CO<sub>2</sub>, tidal volume, respiratory rate, minute ventilation and inspiratory pressure. VMT involved breathing against inspiratory resistance with expiration left unimpeded. Subjects were first required to tolerate 45 minutes to 1 hour of spontaneous breathing prior to the introduction of inspiratory resistance.

Final evaluation was carried out 6 months after initiation of VMT. The results indicated that (1) a specific VMT programme was established and safely carried out for each subject, (2) PaCO<sub>2</sub>, while on the ventilator was abnormally low in 5 or the 6 men (12-25 mmHg), and (3) all subjects increased ventilatory muscle endurance as measured by increased ability to breathe spontaneously post VMT.

### **Cuff deflation as a communication system for ventilatory-dependent patients**

M. Berger, MS, CCC-SP

*Department of Physical Medicine and Rehabilitation, University of Michigan Medical Center, 1500 East Medical Center Drive, Ann Arbor, Michigan 48109, USA.*

The author describes various options available for vocalization in tracheostomized ventilator dependent patients. The use of cuff deflation to achieve vocalization is highlighted. For some patients, this is a preparatory step before the use of an uncuffed tracheostomy tube. The speech language pathologist's role in this programme include evaluation of oral motor functioning, vocal cord functioning and the performance of a language and cognitive/memory screen prior to cuff deflation. With the cuff deflated, the speech/language pathologist works with the patient in coordinating voice onset with ventilatory inspiration, reviews prosody considerations and works with the patient in achieving glottal valving to maximize their usage. The author concludes that cuff deflation and/or placement of a cuffless tracheostomy tube is a reasonable goal for the speech-language pathologists to include as a communicative option with the ventilator dependent quadriplegic patient.

### **Incidence of swallowing problems in quadriplegics**

M. F. Wise, OTR, J. C. Milani, MD

*Dallas Rehabilitation Institute 9713 Harry Hines Boulevard, Dallas, Texas 75220, USA.*

The authors report a retrospective review of records of patients discharged from the Dallas Rehabilitation Institute over a 5 year period between 1981 and 1986 with the primary diagnosis of traumatic quadriplegia. Thirteen percent (21 of 161 patients)

had swallowing problems. These difficulties occurred more frequently (20%) in those quadriplegics admitted within 4 months of injury. An analysis of the cause of swallowing difficulties showed positional effects to be implicated in 8 patients (4 patients with excessive neck extension in a halo vest, 2 patients with excessive neck flexion in a Philadelphia collar, and 2 with inadequate head support in a high back wheelchair). Seven patients showed neurologic deficits secondary to closed head injury. Surgical complications were found in 4 patients (one esophageal laceration, 2 laryngeal nerve paralysis secondary to anterior cervical procedures and 1 patient with transient postoperative edema following an anterior procedure). The authors conclude that there is a high incidence of swallowing problems in new quadriplegics and stress the importance of additional training in the evaluation and treatment of swallowing problems as well as greater care both in patient positioning and in the performance of anterior cervical surgery.

### **Factors affecting neurologic recovery following post-traumatic incomplete paraplegia**

C. C. Edwards, MD, A. M. Levine, MD, M. C. Weigel, MA, J. B. White, MD, J. York, MD

*Division of Orthopaedic Surgery, University of Maryland Hospital, 22 South Greene Street, Baltimore, Maryland 21201, USA.*

The authors noted that current authorities cite widely differing views on the optimum timing for surgery, the significance of residual bone in canal and other treatment variables. To help resolve these dilemmas, a prospective study of 70 incomplete paraplegics was undertaken. Injuries ranged from T4 to L4 and included 14 Frankel A patients in spinal shock with no distal function, 12 Frankel B patients with only sensory function, 21 Frankel C with slight motor strength, and 23 Frankel Ds with weak but useful motor function below their injury. All were treated under the same protocol within 8 days of their injury using the rod-sleeve method to eliminate all kyphotic and translatory deformity. For each patient, the largest pair of sleeves that would fit between the rods and apical facets were utilized to provide maximum lordosis with distraction and rotational stability. Follow up was obtained in all 70 patients. Post-fusion alignment averaged 1° of lordosis and 0.7 mm. of translation. Post-fusion height for the injured vertebra and disc space was 92%. No patient in the series lost residual neurologic function.

To assess neurologic recovery, the strength of each lower extremity muscle group and the sensation for each dermatome prior to surgery was tabulated and retabulated at the last follow up visit. Zero to 5 motor points based on standard physical therapy grading and 0 to 2 sensory points were assigned for each root between L1 and S3. The authors then calculated the percent of initial deficit which each patient recovered. The average patient in this series regained 72% of his neurologic deficit. To identify factors influencing recovery, the percent of return for various possible subgroups was compared. Contrary to expectation, there was no correlation between fracture pattern and neurologic recovery. Dislocations (79% improvement) flexion-compression injuries (69%) and axial load burst fractures (71%) all realized essentially the same degree of recovery. Anatomic level of injury did affect recovery but less than was generally thought. The average patient with a T3 to L1 cord lesion regained 64% versus 72% for T12 through L2 lesions and 81% for pure cauda equina below L2.

Time from injury to surgery had only a small effect on neurologic recovery within the first 48 hours. Patients treated with rod-sleeve reduction had the same amount of recovery whether reduced 4 to 8 hours (71%) or 8 to 12 hours (72%) from injury. Those treated between 12 and 48 hours regained slightly less (62%).

Following rod-sleeve reduction alone, mid-sagittal canal diameters ranged from 50 to 98% of normal on postop CT or tomograms. This permitted myelographic dye passage in 96% of the cases. There was little correlation between postop canal diameter and neurologic recovery. Patients had greater neurologic recovery (63% vs 74%) with res-

toration of at least two-thirds of their spinal canal diameter. However, correction of more than two-thirds canal diameter yielded no further neurologic improvement.

The only factor the authors could identify which affected neurologic recovery with statistical significance ( $p < 0.05$ ) was the magnitude of the initial neurologic deficit. For example, recovery averaged 51% for Frankel A patients who presented in spinal shock with no function, compared with Frankel Bs of 66%, Cs 75%, and Ds 81%.

### **A traumatic spinal cord injury personality: the new data**

D. E. Rohe, PhD, J. Malec, PhD

*Mayo Clinic, Department of Psychiatry and Psychology, Section of Psychology, West 9, 200 First Street SW, Rochester, Minnesota 55905, USA.*

The results of two studies involving non-pathology oriented measures of personality were reviewed. They both found in a mutually complimentary fashion, dramatic homogeneity in personality patterns of males who incur traumatic SCI. A study by Rohe, DE and Athelstan, GT (*Journal of Counselling and Psychiatry* 29:283–291, 1982) using the Strong Campbell Interest Inventory demonstrated significant homogeneity of interests among males and females with SCI. They typically preferred to work alone and with things that are concrete, practical and physical. Their interests were dissimilar from health care professionals and were generally incompatible with post injury physical capabilities, producing major dilemma for vocational and avocational endeavours.

A study by Malec, J. (*Rehabilitation Psychology* 30:165–172, 1985) using the Eysenck Personality Inventory and Derogatis Symptom Checklist (SCL-90) found that traumatic motor-disabled persons were more extroverted and less distressed than persons with non-traumatic disabilities or with traumatically induced pain. Their learning style was oriented toward discovering environmental contingencies through active and repeated challenging of the environment. The relevance of these findings for the manner in which health care professionals interact with and deliver services to males with traumatic SCI was discussed.

### **Play it safe**

E. I. Weinberg, MA, MPH

*Keystone Regional Spinal Cord Injury System, 109 Lothrop Street, Pittsburgh, Pennsylvania 15213, USA.*

The authors present a description of a community prevention/education programme initiated by the Keystone Regional Spinal Cord Injury System in Western Pennsylvania. The programme, called Play It Safe, was initiated in 1984 and has reached an estimated 10 million persons through personal contacts, direct mail, media exposure, printed materials, billboards, educational seminars, health fairs, and school presentations. The authors admit that because of the nature of the programme, it is difficult for KRSCIS to measure direct results. They feel that Play It Safe has played a significant role in reducing the number of spinal cord injuries throughout Western Pennsylvania.

### **Marketing and developing a community-based prevention program – feet first first time**

D. Casuto, RN, MRA, CRRN, A. Rohlf, RN, CRRN, D. G. Soliz, MSW

*Grossmont District Hospital, Physical Rehabilitation Center, 5555 Grossmont Center Drive, La Mesa, California 92041, USA.*

The development and implementation of a SCI prevention programme by the Physical Rehabilitation Unit at Grossmont District Hospital is described. The Feet First First

Time programme has been presented to over 20,000 students at over 75 San Diego city and county schools, as well as other community groups. The programme has been well received by students and has gained financial support from individuals and community agencies. An analysis of prevalence of SCI in San Diego County before and after the programme is planned.

### **Spinal cord injury rehabilitation outcome: the impact of age**

G. M. Yarkony, MD, E. J. Roth, MD, A. W. Heinemann, PhD, L. L. Lovell, BS  
*Rehabilitation Institute of Chicago, 345 East Superior Street, Chicago, Illinois 60611, USA.*

The effect of age on self care and mobility skill performance after spinal cord injury was studied using a 15-task modified Barthel Index (MBI) to score functional abilities for 708 patients aged 6 through 88 years. Analysis of covariance showed no relationship between age and discharge MBI score. Advancing age was associated with increased dependence in only seven functional skills (bathing, upper and lower body dressing, stair climbing, and transfers to chair, toilet and bath) and only for patients with complete quadriplegia, incomplete paraplegia and incomplete quadriplegia demonstrated no relationship between age and skill performance. Results suggest that comprehensive rehabilitation services can improve functional outcomes following spinal cord injury regardless of age.

### **Outcomes of the older patient with spinal cord injury**

M. J. DeVivo, DrPH, P. L. Kartus, MPH, R. D. Rutt, BS, S. L. Stover, MD, P. R. Fine, PhD  
*547 Spain Rehabilitation Center, University of Alabama at Birmingham, Birmingham, Alabama 35294, USA.*

The authors undertook this study to assess the outcome of older patients sustaining spinal cord injury and compare these outcomes with those spinal cord injured patients who were younger. The study was to determine the relationship between age at injury and (1) demographic characteristics such as sex, race, etiology, neurologic level, and extent of lesion; (2) initial system hospital descriptors including time from injury to system admission, length of stay, total hospital expenses and morbidity; and (3) outcome measures of treatment including postdischarge place of residence, number and severity of prespecified medical complications, number of rehospitalizations and days rehospitalized, use of attendant care and two year survival rate. The study included 866 patients admitted between 1973 and 1985. Five age groups were established: (1) 1 to 15 years of age ( $n = 40$ ), (2) 16 to 30 years of age ( $n = 60$ ), (3) 31 to 45 years of age ( $n = 166$ ), (4) 46 to 60 years of age ( $n = 100$ ), and (5) 61 to 86 years of age ( $n = 70$ ). In the older age group (age 61 to 86), more spinal cord injuries resulted from falls (46%) than from motor vehicular accidents (38%). Acts of violence ranked third (7%). In the 16 to 30 year age group, motor vehicular accidents accounted for 55%, acts of violence 23%, sports 11%, and falls 7% of injuries. Older patients were more likely to be female, black and quadriplegic and to have neurologically incomplete lesions than their younger

counterparts. Older patients (age 61 to 86) were two times more likely to develop pneumonia, two times more likely to require artificial ventilatory support, almost three times more likely to experience gastrointestinal hemorrhage, 5.6 times more likely to develop pulmonary emboli and 16.8 times more likely to have a renal stone than patients aged 16 to 30.

The hospital charges for the initial period of hospitalization increased by \$77.50 for each year of age of injury. Higher charges occurred despite the fact that no relationship was observed between age at injury and initial hospital length of stay or days from injury to system admission. Patients in the older age group (age 61 to 86) were 23 times more likely to be discharged to a nursing home, 72 times more likely to reside in a nursing home 2 years postinjury and four times more likely to need rehospitalization during the second postinjury year than their 16 to 30 year old counterparts. One year and 2 year survival rates for patients aged 61 to 86 were 67% and 59%. In the absence of spinal cord injury, the expected 2 year survival rate for patients in this age group was 94%. Two year survival rates by Frankel Grade for patients in the oldest age group were: Frankel A 33%, Frankel B 53%, Frankel C 63% and Frankel D 91%. These data demonstrate the comparatively poor prognosis of the older spinal cord injured patient with a neurologically complete lesion.

#### **Aldosterone regulation in high spinal cord transection**

D. A. Sica, MD, M. Midha, MD, G. Bergen, RN, I. Fakhry, BS, R. Hussey, MD  
*Division of Nephrology, MCV Station Box 160, Richmond, Virginia 23298, USA.*

Eight chronic high level SCI patients were studied to determine their aldosterone response to a range of established stimuli. After a minimum of 3 days on a stable sodium intake, subjects were administered on sequential days 1) intravenous ACTH, 2) angiotensin II, 3) intravenous metoclopramide, and 4) head-up tilting. Plasma was obtained at specified time intervals for determination of aldosterone. The observed aldosterone response proved to be quite variable dependent upon the stimulus being employed. Graded dose ACTH was observed to normally stimulate aldosterone over a full physiologic range, indicating normal sensitivity and capacity of aldosterone secretory response to ACTH in SCI. A rise in plasma aldosterone occurred in response to only the highest doses of angiotensin II, suggesting that the aldosterone release mechanism is somewhat insensitive to angiotensin II in SCI. Metoclopramide administration elicited a rise in plasma aldosterone similar to that observed in normals although responses were heterogeneous. The level of tilt employed (45 degrees) proved sufficient to decrease mean arterial pressure in the majority of subjects studied. Plasma aldosterone rose in response to the postural hypotension. The continued increase in plasma aldosterone levels at 60 minutes into the study (30 minutes in the supine position) suggests an exaggerated response. From a clinical standpoint aldosterone release in SCI represents an aggregate response to multiple simultaneous stimuli and is apt to reflect the interplay of a number of factors.

Initial ( $p = 0.02$ ), VR Initial ( $p = 0.009$ ), and AL Initial ( $p = 0.08$ ). Interpretation of these results was confounded by the age distribution in the closed head injury and non-closed head injury groups. The non-closed head injury group was significantly older and were more frequently ethanol or substance abusers. Although they admitted it is difficult to identify a precise relationship between acute and chronic factors in neurocognitive performance, the authors feel that age, education, alcoholism and substance abuse appear to contribute substantially to impaired neuropsychological performance and suggest restriction and/or statistical control for these confounding variables in future studies in this area. The authors conclude that their data reinforced the developing consensus that many acute SCI patients have associated deficits in attention, concentration, visual and verbal problem solving ability.



**Pressure sore profile: cost and management**

G. W. Wharton, MD, J. C. Milani, MD, L. S. Dean, RN, MSN

*Metroplex Regional Spinal Cord Injury Program, Dallas Rehabilitation Institution, 9713 Harry Hines Boulevard, Dallas, Texas 75220, USA.*

The authors present a retrospective analysis of 50 patients admitted to the spinal cord injury service at the Dallas Rehabilitation Institute, for the treatment of pressure sores. The patients included 45 males and 5 females ranging in age from 13 to 63 years (mean 29.86 years). Time from onset of spinal cord injury to onset of pressure sores ranged from 1 month to 25 years (average 6.43 years). Ischial sores were the most common, followed by sacral, trochanteric and sores at other anatomic locations. Flap coverage was required in 34 cases followed by skin grafts in 5 cases, 1 tendon release and 1 debridement. Six cases required no surgery and 3 cases were felt to warrant surgery but refused. The patients were maintained at bed rest from a range of 2 days to 156 days (average 34.5 days). They spent an average of 66.5 days in the hospital (range of 11 days to 191 days). The average cost of pressure sore treatment including costs of hospital room, surgeons' fees, medications, supplies and bed rentals was \$69,587. Cervical injuries averaged \$91,271, thoracic injuries averaged \$56,181 and lumbar injuries averaged \$42,984. The authors conclude that their costs for treating pressure sores are significantly higher than previous estimates and that patients with greater neurologic impairment and those with larger or deeper sores also required more expenditure.

**Comparison of low dose heparin, low dose heparin plus dihydroergotamine, low dose heparin plus electrical stimulation, and placebo as prophylaxis for deep vein thrombosis in acute spinal cord injury**

G. J. Merli, MD, G. Herbison, MD, H. H. Weitz, MD, E. H. Weitz, MD, E. Posuniak, DO, J. HENZES, BS, C. Park, MD, J. Ditunno, MD, M. Jaweed, MS

*Division of Internal Medicine, Suite 4138, Thomas Jefferson University Hospital, Philadelphia, Pennsylvania 19107, USA.*

Current treatment modalities for deep vein thrombosis are directed at stasis and hypercoagulability. Low dose heparin (5,000 U, SC, q.8 hrs.) is the recommended prophylaxis for the former and external pneumatic compression sleeves for the latter in spinal cord injury patients. Because of the cumbersomeness of the former and relatively ineffective results in the former, new methods were sought. Electrical stimulation has been shown to be effective during surgery to prevent deep venous thrombosis in a non-spinal cord injured population by improving blood flow. Second, dihydroergotamine, a venotonic agent which increases venous return has been shown to be an effective prophylaxis in combination with low dose heparin for deep vein thrombosis in general surgery. The hypothesis of the authors study was based on the assumption that deep venous thrombosis in spinal cord injured patients would be prevented by decreasing hypercoagulability and stasis. The purpose of the study was to demonstrate the efficacy of low dose heparin, dihydroergotamine and electrical stimulation alone or in combination in the prevention of deep vein thrombosis in acute spinal cord injured patients over a 28-30 day period.

In a prospective, randomized trial the authors selected insensate patients with motor complete or non-functional motor incomplete C2 to T11 lesions less than two weeks post injury. One hundred patients fulfilled the criteria and were screened for deep vein thrombosis by I<sup>125</sup> fibrinogen scan and impedance plethysmography. Venography was performed to confirm a positive non-invasive test. Sixty six patients were randomized to one of four treatment groups: placebo (n = 18), low dose heparin (n = 17), low dose heparin plus dihydroergotamine (n = 15), and electrical stimulation plus low dose heparin (n = 16). The patients in the above groups received daily I<sup>125</sup> fibrinogen scanning for 28 to 30 days. Positive non-invasive studies were verified by venography. Upon completion of the study all patients had bilateral leg venography. Five patients in the treat-

ment groups were not included in the statistical analysis due to protocol compliance reducing the analysis to 61 patients.

The results show deep vein thrombosis developed in 8/17 (47%) in the placebo, 8/16 (50%) in the low dose heparin, 7/13 (53%) in the low dose heparin plus dehydroergotamine, and 1/15 (6.7%) in the electrical stimulation plus low dose heparin groups. The authors concluded that in insensate motor complete and non-functional incomplete C2 to T11 acute spinal injured patients, low dose heparin and dehydroergotamine alone or in combination did not effectively reduce the occurrence of deep vein thrombosis. Electrical stimulation plus low dose heparin did significantly ( $p < 0.05$ ) reduce the incidence of deep vein thrombosis. A larger multi-centre trial will be necessary to further assess the effectiveness.

### **Posterior bladder neck ledge – a complication unique to the neuropathic bladder**

I. Perlash, MD, G. Friedland, MD

*VA/Stanford University Medical Center, Palo Alto, California 94304, USA.*

A transrectal linear array sonographic examination has demonstrated a posterior bladder neck ledge in spinal cord injured patients. The authors used a Toshiba Model SAL 30, with 3.5 mhz ultrasonic rectal probe which housed a 64 piezoelectrical elements arranged linearly at the tip. The probe was surrounded with a water filled sheath which was lubricated with an acoustic jelly and inserted intrarectally with the window facing anteriorly. Patients were examined in the lithotomy position. The ultrasound study showed sagittal images of the bladder, prostate, seminal vesicals and urethra. There were 125 out of 339 patients who had ledges of 0.5 cm. to 2 cm. The duration of catheterization and association of detrusor sphincter dyssynergia were factors leading to development of the longer ledges. Transurethral sphincterotomy with incision at 2 and 10 p.m. provided satisfactory treatment for these patients.

### **Liver response in spinal cord injury**

D. F. Apple, Jr, MD, T. Krueger, BBA

*Shepherd Spinal Center, 2020 Peachtree Road, NW, Atlanta, Georgia 30309, USA.*

During the summer of 1986, three patients with traumatic spinal cord injury requiring surgery for their injury, were refused anesthetic agents due to elevated liver enzymes. The authors reviewed the general trauma, liver trauma, enzyme, and spinal cord injury literature without finding any significant explanation of liver enzyme elevation or any indication that it had any pathologic significance. One hundred and three consecutive traumatically injured patients had records reviewed in a retrospective manner. Admission laboratory data including white blood cell count, hemoglobin and hematocrit, LDH, SGOT, bilirubin, protein and gamma GT done initially and on subsequent tests were tabulated. Also surveyed was whether the patient had had a history of hepatitis, drug abuse or had undergone spinal surgery. Follow up review was limited to the development of hepatitis, the minimum follow-up being six months. The patient population was divided into those patients who had a history of substance abuse, and those who did not. There was no significant difference in their degree of enzyme elevation. Another group was of patients who had associated chest and abdominal trauma. Again, there was no significant difference in the number with elevated enzymes and the degree of elevation. Of the one hundred and three patients, two had a history of hepatitis, both in the substance abuse group. No patient developed hepatitis in the follow-up period.

The author felt that spinal cord injury per se does not cause elevation of liver enzymes, as 31% of this group did not have any enzyme elevation. Within this group, there were

patients who had had a history of hepatitis, substance abuse and had sustained chest and abdominal problems. The authors concluded that the elevated liver enzymes in spinal cord injured patient does not indicate a serious medical problem and does not indicate a significant anesthesia risk factor.

### **Nutritional assessment and estimation of energy requirements in traumatic quadriplegia**

R. H. Lerman, MD, PhD, M. H. Kerrigan, MS, RD, E. A. Shapiro, MD, P. W. Jannace, MD, S. B. Tiller, RD, M. M. Freed, MD

*Clinical Nutrition Unit, Evans Memorial Department of Medicine, Departments of Clinical Dietetics & Rehabilitation Medicine, University Hospital, Boston University Medical Center, Boston, Massachusetts, USA.*

The authors studied 17 male and 5 female C2 to C6 inpatient quadriplegics who ranged from 1·2 months to 20 years post injury, measuring the basal energy expenditure by indirect calorimetry. The compared measured energy expenditure with calculated expenditure utilizing the Harris-Benedict equation e.g. for males:  $BEE = 66·5 + 13·8 (Wt. \text{ in kg.}) + 5·0 (Ht. \text{ in cm.}) - 6·8 (age)$ . Multiple linear regression was used to generate a formula to predict measured basal energy expenditure:  $BEE = 1,838 - 332 (sex) - 282 (time \text{ post injury}) + 11·1 (TSF) - 7·8 (age) + 22·8 (MAMC)$ , where male sex = 1, female sex = 2, time post injury = 1 for subacute (1-4 months post injury) and 2 for chronic (greater than 11 months post injury), TSF = triceps skin fold (mm), age is in years and MAMC—mid arm muscle circumference (mm). This regression equation was found to be a much better predictor of basal energy expenditure in chronic quadriplegia than the Harris-Benedict equation. The authors do not recommend the usage of this form until follow up studies have been undertaken to test its reproducibility.

### **Clostridium difficile enterocolitis: twenty one cases treated on a spinal cord injury service**

T. J. McGuire, MD, R. A. Lueck, MD

*Craig Hospital, Rocky Mountain Regional Spinal Injury Center, Englewood, Colorado, USA.*

The authors reviewed charts of 21 spinal cord injured patients with positive clostridium difficile stool assays. Clinically, 19 presented with watery involuntary bowel movements and 17 had a stool frequency of greater than three times a day. Fourteen patients had a fever greater than 37·5° C. Abdominal pain occurred in only 5 patients. Prior antibiotic therapy had been given to 11 patients, usually for pulmonary, soft tissue, urinary tract, or bone infection.

The criteria used to determine involved therapy was the patients inability to participate in therapy for 30 minutes or less as the result of uncontrolled bowel movements. 'Lost' therapy days occurred when the patient was not able to participate in any therapy because of uncontrolled bowel movements. Patients with *C. difficile enterocolitis* lost 1 day and had 2 days involved in regards to physical therapy and 1 lost day and 1 involved day regards occupational therapy. The authors looked at the possibility of immunocompromised states. Previous antibiotic therapy indicated there was no significant differences that could be demonstrated. Because of the pattern of clustering noted in the positive *C. difficile* toxin assays, it was suggested there was some nosocomial spread of the infection.

Treatment of *C. difficile enterocolitis* involves both the antibiotic eradication of the organism and isolation measures. All associated antibiotic use in patients with *C. difficile enterocolitis* should be reviewed and oral penicillins and cephalosporins avoided. Recommended antibiotic treatment is Vancomycin 125-500 mg. orally every 6 hours for 5 to 10 days or metronidazole (Flagyl) 250 mg orally four times a day for 10 days.

Isolation procedures included enteric isolation and sporicidal disinfection with an agent as alkaline gluteraldehyde for highly contaminated articles such as bedpans and sigmoidoscopes.

#### **Bladder evacuation by sacral nerve stimulation: an update**

A. Talalla, MD, J. W. Bloom, PhD, Q. Nguyen, BEng

*Department of Surgery, McMaster University, 1200 Main Street, West Hamilton, Ontario, Canada L8N 3Z5.*

Six patients suffering from detrusor hyperreflexia and detrusor/urethral sphincter dyssynergia due to functionally complete traumatic spinal cord transection have undergone coupling of tripolar cuff electrodes to extradural sacral nerves controlling bladder function. Of these, 3 patients, all women with midthoracic lesions, have effectively voided urine by sacral nerve stimulation, one over a period of 28 months. In none of these has the voiding been consistently effective. The remaining three patients have not yet voided using their stimulators.

#### **Intravesical stimulation for bladder areflexia**

J. B. Nanninga, MD

*Northwestern University Medical Center, Chicago, Illinois 60611, USA.*

Intravesical stimulation was used in 8 patients with incomplete spinal cord injury and urinary retention. The cathode was placed per urethra into a saline filled bladder. The anode was placed on the lower abdomen or lower extremity. Stimulation was performed at a pulse width of 0.2 – 0.4 msec., 60–80 Hz and current up to 80 mA. Stimulation was carried out for 15–60 minutes five to seven times per week. To date 8 patients have been treated. Two patients regained function 6 months after injury. This study suggests the use of intravesical stimulation in spinal cord injury patients with a non contractile bladder.

#### **Determination of residual urine volumes using ultrasound**

D. D. Cardenas, MD, E. Kelly, RN, J. N. Krieger, MD, W. H. Chapman, MD

*Department of Rehabilitation Medicine, R7-30, University of Washington School of Medicine, Seattle, Washington 98195, USA.*

This study was used to determine if a portable ultrasound scanner, a BVI 2000, could be used to determine bladder volumes. There were 15 patients tested who underwent 224 ultrasound determinations and 57 urethral catheterizations. The results indicate that the ultrasound scanner tended to underestimate the catheterized volumes. The average error for volume ranging from 50–700 ml. was 18% which compares favourably with both real time scanning using standard equipment and other portable instruments.

#### **Effects of botulinum A toxin on detrusor-sphincter dyssynergia in spinal cord injured patients**

D. D. Dykstra, MD, A. A. Sidi, MD, A. B. Scott, MD, J. M. Pagel, MD, G. D. Goldfish, MD

*Department of Physical Medicine and Rehabilitation, University of Minnesota Hospital, Box 297, Minneapolis, Minnesota 55455, USA.*

The authors evaluated the ability of low doses of botulinum A toxin, an inhibitor of acetylcholine release, to denervate and relax the spastic external urethral sphincter in 11

spinal cord injured patients with detrusor-sphincter dyssynergia. Baseline cystometric studies were conducted prior to treatment. Various doses of toxin were injected percutaneously or through a cystoscope directly into the sphincter muscle. Sphincter denervation, decreased residual urine volume, and increased urine flow were observed in 8 patients. These effects usually lasted an average of 1.6 months, after which time another injection was needed. The toxin also decreased autonomic dysreflexia in four patients. These data indicate that botulinum A toxin is useful in treating spinal cord injured patients with detrusor-sphincter dyssynergia.

#### **Efficacy of penile prosthesis in men with spinal cord injury**

F. P. Ekrem, MD, T. J. Hanson, MD, J. L. Merritt, MD, D. M. Baret, MD  
*Mayo Clinic, Department of Physical Medicine and Rehabilitation, 200 First Street, Rochester, Minnesota 55905, USA.*

To evaluate the efficacy and postoperative patient and partner satisfaction of penile prostheses in men with spinal cord injury, 27 men who had penile prostheses implanted at the Mayo Medical Centre were surveyed by telephone. Sixteen were paraplegic and 11 were tetraplegic. Follow up was at 4 to 9 years. The Jonas semirigid rod was used in 7 patients and the inflatable prosthesis was used in 20 patients. Among the reasons for the implant were sexual satisfaction, better condom catheter placement, and improved self-image. Seventeen patients (63%) were satisfied with the implant, 2 patients could not judge and 8 were dissatisfied. The satisfaction rates for the Jonas rod and the inflatable type were comparable but only 5 of 20 reported no problems with the inflatable prosthesis.

#### **Autoinjection for erection in the spinal cord injured male**

D. R. Bodner, MD, R. Lindan, MD, E. Loeffler, RN, W. Taylor, RN, M. I. Resnick, MD  
*Cleveland VA Medical Center, 10701 East Boulevard, Cleveland, Ohio 44106, USA.*

Obtaining and sustaining adequate erections for penetration can be a problem for men with spinal cord injuries. Until recently, the only effective therapeutic option for the spinal cord injured patient with erectile dysfunction was the placement of the penile prosthesis. A high complication rate has been noted in this patient population after a prosthesis is placed. The authors gained experience with autoinjection of the corpora cavernosa in spinal cord injured patients using paraverine (a smooth muscle relaxant) and phentolamine (an alpha-blocking agent) to obtain and sustain erections. The dosage used is titrated for each patient. Complications have included ecchymosis and priapism.

#### **The effectiveness of assertiveness training in acute spinal cord injury patients**

J. M. Cressy, M. Atkins, OTR, R. H. Adkins, PhD  
*Rancho Los Amigos Medical Center, Downey, California 90242, USA.*

A comparison study was undertaken to determine the efficacy of assertiveness training with SCI patients. The proposed purpose of assertiveness training is to give patients skills which enable them to protect their rights while respecting the rights of others. This study sought to verify that learning these skills will make the transition from hospital back into society less traumatic. A group of SCI patients who received assertiveness training was matched for age, sex, level of injury, and education with another group that did not receive assertiveness training. Both groups were given the 30-item Rathus Assertiveness Scale as well as a 20-item discrimination test which required

differentiation between assertive, aggressive, and passive behaviour. Tests were given pre- and post-training. In order to measure changes in behaviour, significant other people were also asked to rate interpersonal behaviour 1 month post-discharge. Preliminary data showed that patients became more aware of their behaviour and the behaviour of others. A significant increase was seen in the didactic post-testing. The training consisted of two 90-minute sessions given in a class format and utilized videotapes, lecture, group discussion, and role playing. Since certain social skills are an acquired behaviour, it is felt that learning the material in these courses will enable patients to gain more control over their lives by enhancing their ability to communicate with those in their environment.

**Creekview 202—A community living alternative for ventilator dependent quadriplegics: one year later**

K. McKay, OT(C), N. Haw, ARW, R. Dunfield

*Neil Squire Foundation, 451-810 West Broadway, Vancouver, BC V5Z 4C9 Canada.*

Five ventilator dependent quadriplegic men and 1 C4 complete quadriplegic man who had lived, for 1½ years to 13 years in an extended care institution moved into a shared apartment in downtown Vancouver, British Columbia in September 1985. Their ages ranged from 22 to 34 years and levels of injury varied from C1 to C4 complete quadriplegia. All residents played a central role in the initiation, planning and design of this housing project; an effort involving 5 years of dedicated work by numerous community and government organizations. The residents attended an informal lecture series designed to update them on all aspects of their health care prior to the move to Creekview 202. They then played an integral part in the selection and training process of their live-in attendant staff.

Retrospective and prospective data collected from 1 year prior and following the move, indicated that in the first year: (1) resident's health status was clearly maintained, (2) a significant reduction in total cost was recorded by maintaining this group in the community and (3) the quality of staffing administered through a community agency was found to be of a high standard.

With co-operative community and government support, shared apartment living provides a cost-effective and quality lifestyle for ventilator dependent quadriplegic persons.

**Trazodone HCL in the treatment of dysesthetic pain in traumatic myelopathy: a randomized, double-blind, placebo-controlled study**

G. Davidoff, MD, M. Guarracini, MD, E. Roth, MD, J. Sliwa, DO, G. Yarkony, MD  
*Department of Physical Medicine & Rehabilitation, Box 0042, University of Michigan Hospital, Ann Arbor, Michigan 43109, USA.*

Dysesthetic pain following traumatic myelopathy is characterized by diffuse burning, stinging and tingling sensations distal to the level of injury. The authors indicated recent laboratory evidence which suggested that antidepressant medications with selected inhibition of serotonin reuptake in the brain may be associated with superior analgesic effect compared to such non-selective agents as amitriptyline. Trazodone hydrochloride is a potent presynaptic serotonin reuptake blocker with a few anticholinergic and cardiovascular side effects. A double blind study was developed. Following a 2 week placebo lead in period, patients were randomized to a 6 week course of 150 mg of Trazodone hydrochloride per day or placebo. Evaluations of pain quality and intensity were performed at 2 week intervals using the Melzack-McGill Pain Questionnaire, Sternbach Pain Intensity Scale and Zung Pain and Distress Index. Neurologic examination and assessment of side effects were performed at each evaluation session.

Results showed there were no significant changes in reported pain measures between patients allocated to the active drug group and those given placebo. However, significantly more patients randomized to trazodone complained of side effects and prematurely terminated their participation in the study. The authors concluded that trazodone may not be effective in the control of central pain syndromes.

#### **Employment after spinal cord injury**

M. J. DeVivo, PhD, R. D. Rutt, BS, S. L. Stover, MD, P. R. Fine, PhD  
*547 Spain Rehabilitation Center, University of Alabama at Birmingham, Birmingham, Alabama 35294, USA.*

In order to identify a comprehensive but manageable set of determinants capable of influencing return to employment after spinal cord injury (SCI) and to develop a predictive model for the postinjury vocational potential of SCI persons, a retrospective study of 154 patients treated at the University of Alabama SCI Care System between 1973 and 1979 was conducted. Subjects were between 13 and 59 years of age at injury and were followed for 7 years. Study subjects were divided into 4 groups: (1) those who were always unemployed postinjury, (2) homemakers, (3) students, and (4) those who were employed at least briefly postinjury.

The proportion of employed subjects increased with time. During the 7th postinjury year, 19.4% of the subjects were employed. Conversely, the proportion of persons attending school declined to only 6.5% at 7 years postinjury. Overall, 51.3% remained unemployed throughout the 7 year follow up period, 8.4% became homemakers but were never employed or in school, 10.4% returned to school but were never employed and 29.9% were employed at least briefly during the first 7 years postinjury. A predictive model was developed based on 7 variables that were significantly associated with postinjury employment status: (1) sex, (2) motivation to work, (3) whether the patient's last job required ambulation, (4) race, (5) education level, (6) Barthel Index, and (7) whether the patient had children.

The model's overall predictive accuracy was 79%. It appears the vocational rehabilitation potential of SCI patients is discernible using a small set of predictor variables. However, use of any predictive model is meant to supplement and not replace clinical judgement.

#### **Community re-entry group, an alternative approach**

J. McCauley, OTR/L, BS, OT, B. Sullivan, OTR/L, BS, OT  
*Rehabilitation Institute of Chicago, Occupational Therapy Department, 345 East Superior Street, Chicago, Illinois 60601, USA.*

An interdisciplinary Community Re-Entry Group for persons with limited lower extremity involvement (CRG) was established at the Rehabilitation Institute of Chicago in 1983. Its primary goal was to maximize independence in physical, social, and leisure skills. The group met daily for 1 to 2 and 1½ hours and community activities occurred three times a week. The Group was led by an occupational therapist and recreational therapist.

In order to improve feedback to primary therapists about patient progress in the CRG, first a formal system of program evaluation with nine objectives was established in 1986. A 3 month pilot experience with the major measurement instruments for meeting the CRG's objectives was described. The advantages and disadvantages of using such a program evaluation tool for new group activities is discussed.

### **Community re-integration of spinal cord injured persons: problems and perceptions**

C. Harrison, BS, J. Kuric, RN, BSN, CCRN

*Southeastern Michigan Spinal Cord Injury System, Rehabilitation Institute, 261 Mack Boulevard, Detroit, Michigan 48201, USA.*

A survey of 222 SCI patients treated by the Southeastern Michigan SCI System was conducted to explore some key issues involving community re-integration problems. The 62 respondents (28%) did not differ from non-respondents on demographic and health status variables and were consequently considered representative of the total patient population.

Important findings included: (1) 30% were non-compliant with prescribed medications, (2) 25% had not received all equipment prescribed during initial rehabilitation, (3) 45% indicated their current residence was not completely accessible, (4) 73% were primarily dependent on others for transportation, (5) 77% do not participate in any organized leisure activities outside their home, (6) 8% were currently working, compared to 39% employed prior to injury, (7) 47% indicated transportation problems and 42% indicated accessibility to public places as the main obstacles to their adjustment to SCI.

A vicious cycle appears to trap many SCI patients. Lack of transportation resources and poor accessibility restrict utilization of currently available educational, occupational, and recreational opportunities. Without participation in the community, transportation and accessibility needs are not recognized by those in the community who have the ability to initiate change.

### **F-wave abnormality as an indicator of post-traumatic syringomyelia**

F. M. Dyro, MD, D. K. Foo, MD

*Departments of Neurology and Spinal Cord Injury, Veterans Administration Medical Center, 1400 VFW Parkway, West Roxbury, Massachusetts 02132, USA.*

Post-traumatic syringomyelia, a serious, late complication of spinal cord injury, must be differentiated from neurological deficits produced by underlying pathology in the cervical region such as spondylosis or spinal stenosis. Diagnostic studies available include electrodiagnostic studies, gas myelography, myelography with spinal CT and more recently, MRI scanning. The most readily available and least costly study is electrodiagnostic evaluation. Preliminary studies have shown that measuring F response may be useful in detecting patients with early cyst formation in post-traumatic and congenital syrinx. The F response is believed to represent centrifugal discharges from individual motor neurons initiated by antidromic volleys along their axons so that the afferent and efferent limbs of the F response consist of the same alpha motor axons. These responses are readily obtained by stimulating a peripheral nerve with a stimulus of 25% above the supra-maximal stimulus needed to produce an M wave or direct muscle response. Latency, form and amplitude of the F wave depend upon the available pool of responding axons, the size of the motor unit territory, and conduction along proximal portions of the nerve roots. In normal subjects, F response from the hand intrinsics usually have a latency of less than 30 sec with variation of 1 to 1½ msec between the F response with the shortest latency and that with the longest latency.

Thirty patients from the Spinal Cord Injury Unit were evaluated in the EMG laboratory when new symptoms developed. Based on these patients, the authors felt that prolongation of the F wave latencies with less than 2 msec of variation is a feature of syrinx and enabled them to differentiate the syrinx from a root lesion. Five of the patients had symptoms found to be the result of root encroachment. F wave minimum latencies were normal or mildly prolonged but difference between minimum and maximum F wave latencies were as much as 10 msec. In patients with peripheral entrapment, F wave latencies were not significantly prolonged and there was only a normal degree of latency variation. In those patients with diagnosed syrinx with abnormal latencies that were



ultimately operated upon, the latencies returned to normal following drainage of the cyst. The authors feel that F wave measurements are simple and a sensitive test of anterior horn cell and proximal root function and are useful for monitoring improving response of the anterior horn cell postoperatively.

### **Surgical resection of heterotopic ossification: experience and outcome**

S. L. Stover, MD, J. R. Tulloss, MD, K. M. Niemann, MD

*University of Alabama, Department of Rehabilitation Medicine, Birmingham, Alabama 35294, USA.*

The incidence of heterotopic ossification (HO) following spinal cord injury varies between 16% and 53%. In the majority of the patients, the extent of HO is minimal causing few or no clinical signs or symptoms. Prophylactic treatment with etidronate disodium has been beneficial. In 1 and 5% of all spinal cord injuries, the extent of HO is of such severity that surgery needs to be considered. Twenty eight spinal cord injury patients were reviewed who had 38 procedures for heterotopic ossification. There were 20 men and 1 woman with 18 surgical procedures on the right and 19 surgical procedures on the left hip. Surgery was considered when there was limitation of motion which led to functional impairment and/or postural changes which predisposed to pressure ulcers. Surgery was not considered for at least 6 to 8 months after the onset of HO to allow decrease in the vascularity to the bone and have better demarcation of the bone mass.

With the advent of improved methods of bone bleeding control at surgery and attention to eliminate any sources of infection such as urinary tract, the complications have been reduced. Surgical dissection was maintained extraperiosteally. A wedge of bone was removed with an osteotome to obtain 90° hip flexion. The dead space was minimized by trimming down the edges of the wedge from a V-shaped section to a gentle saucerization. Postoperatively, prophylactic antibiotics were used in all but one case. Suction drainage was used routinely and discontinued depending on the amount of drainage and clinical judgement. Full sitting was usually obtained about 7 to 14 days after surgery.

Complications included infection, fractures, and recurrence. To decrease the incidence of recurrence, etidronate disodium 20 mg/kg/day were given for 2 weeks preoperatively and decreasing to 10 mg/kg/day postoperatively. This prevents recurrence in most patients as long as the drug is given. Recurrence with or without treatment seems to be more dependent on the size of the bony mass than on the length of time following injury until surgery is performed. Less recurrence is seen in head injury patients where neurologic recovery recurs, suggesting that there may be some neural control over this type of mesenchymal metaplasia.

The authors concluded it is possible to perform surgery with relatively few complications and that recurrence continued to be the biggest problem. Improved function was demonstrated during follow up in about 60% of the procedures. The authors concluded that when considering HO surgery for each patient, one must weigh the limitations of the patients function against the risks and possible benefits of surgical intervention.

### **Spinal cord insults and heterotopic ossification in the pediatric population**

D. E. Garland, MD, S. T. Shimoyama, MD, C. Lugo, MD, D. Barras, MD, I. Gilgoff, MD

*7601 East Imperial Highway, Downey, California 90242, USA.*

One hundred fifty two patients were reviewed for the presence of heterotopic ossification (HO). Fifteen developed heterotopic ossification at 19 locations. Spinal cord levels were 13 thoracic and 2 cervical and the average age of the patient was 8.5 years. Average time to detection of HO from the spinal insult was 6.5 years. The hip was involved in 15 of 19 HO lesions. The most common physical finding was a decreased range of motion in the

affected extremity. Alkaline phosphatase was elevated in 5 patients at the time of detection.

Five patients had neurogenic HO develop at an average age of 13 ½ years. The hip was involved in 6 of 7 instances. The average time to diagnosis was 14 months after injury. Ten patients had concomitant etiologic factors such as surgery, decubitus ulcers, late neurogenic hip dislocation and late acute local trauma influencing HO formation. Three patients had some absorption of the HO while one had nearly complete resorption.

The authors in comparing pediatric HO to adult HO felt that there was a lower incidence in the children and that its onset was delayed compared to the adult. Significantly, the HO lesion has the potential to resorb in this population. The authors felt that it may be the secondary form of HO, not neurogenic that is the most significant clinical entity.

#### **Scoliosis in the pediatric spinal cord injured population**

R. R. Betz, MD, W. W. Dearolf, III, MD, J. Levin, MD, L. C. Vogel, MD, M. Clancy, MD, H. H. Steel, MD  
*Shriners Hospitals for Crippled Children, Philadelphia Unit, 8400 Roosevelt Boulevard, Philadelphia, Pennsylvania 19152, USA.*

To evaluate the incidence, severity and treatment of paralytic scoliosis in the pediatric spinal cord injury population, data was reviewed on 155 spinal cord injured with a minimum follow up of 1 year. Preadolescent patients included girls under age 12 and boys under age 14. Etiology was trauma in all but 5 patients. Patients with myelodysplasia and polio were excluded. There were 61 preadolescent patients followed for an average of 50 months and 94 postadolescent patients followed for an average of 26 months. Fifty-seven of the 61 preadolescent patients developed scoliosis greater than 10° for an incidence of 97%. Two patients who did not develop a curve were males, both injured at age 13½. Forty one, or 48% of the postadolescent patients developed paralytic scoliosis. In the preadolescent group, the average curvature was 32° and 73% of the patients developed curves greater than 20°. In contrast, postadolescent group averaged 20° of curvature but only 36% of the group developed curves over 20°. In neither of the groups did the level of injury, completeness of the injury or ambulatory status correlate with the severity of spine deformity. Answering the question of the number of patients who require fusion, over 23 preadolescent injured patients who were followed postadolescence with 9 or 39% of those requiring fusion. In the postadolescent group, 5 of the 85 patients or 6% required surgery. Bracing was recommended for 18 patients, three of these refused and two of these developed curves of 60° requiring surgery. Of 12 patients followed for 24 months, 2 progressed to surgery, 1 patient has progressed 8° and 9 are within 5° of prebrace curve. Complications in those having fusions were 5 with pseudarthrosis and 4 with infections. The high rate of pseudarthrosis confirms the necessity of aggressive approach despite the use of Luque instrumentation. Combined anterior and posterior spine fusion or routine re-exploration of the posterior spine fusion. The authors concluded that scoliosis developed in 97% of the preadolescent patients with 39% of these patients requiring fusion. Scoliosis developed in 48% of the postadolescent patients and progressed an average of 5° a year. Fusion was necessary in only 6%. Surgery carried a high risk of complications noted in half the preadolescents and 4 of 5 postadolescent patients.

#### **Extracorporeal shock wave lithotripsy in paraplegia and quadriplegic patients**

S. Wahle, MD, E. V. Kramolowsky, MD, S. Loening, MD  
*Department of Urology, University of Iowa Hospitals and Clinics, Iowa City, Iowa 52242, USA.*

Thirty one paraplegic and quadriplegic patients were treated with extracorporeal shock wave lithotripsy (ESWL) for renal calculi. Eleven patients had bilateral stone disease. Twenty one (50%) of the renal units treated had large branched calculi. A total of 54

treatments were performed on the 31 patients; 14 patients required more than one treatment with 3 requiring three treatments and 3 patients requiring four treatments. All patients were given preoperative intravenous antibiotics. The number of shocks ranged from 1200 to 3200. Postoperative fever greater than 38.5° C occurred in 22% of patients. At 3 months follow up on 19% of renal units were stone free; however, 52% had greater than 70% reduction in stone volume. Since retreatment seems to be well tolerated, the authors feel that ESWL offers a safe, non invasive and effective method of treating urinary calculi in this group of patients.

### **Success versus failure of the spinal cord injured driver: review of a 5–10 year driving period**

G. Gurgold, BS, OTR

*Rehabilitation Institute, Inc., 261 Mack Boulevard, Detroit, Michigan, 48201, USA.*

Twenty spinal cord injured drivers were chosen at random from over 400 SCI patients completing the Driver Evaluation Training Programme of the Rehabilitation Institute of Detroit. Ten drivers had quadriplegia and 10 had paraplegia. A combined total driving experience of 149 years was represented, with many subjects driving 5–10 years post injury with adaptive equipment. Tabulated information included type of disability, years driving prior to injury, how injured, years and type of vehicle driven post injury, accumulated ticket violations, and accident rate. Fifteen per cent of the SCI drivers were involved in an accident and 2 were at fault. Nine drivers had received various moving violations. No substantial point accumulation was established jeopardizing individual driving privileges. After obtaining interview data, driving records were verified with the Secretary of State. These reviews found the interview data accurate over the past 3 year driving period. Although this pilot study was too small for conclusive results, it supports previous studies showing SCI drivers are safe behind the wheel.

### **Seating consideration for the adult SCI patient**

L. Graf, PT, BS, M. Stalvey, PT, MS, R. Gyves, MA

*Physical Therapy Division, University of Michigan Hospitals, UH 1F249/0046, 1500 East Medical Center Drive, Ann Arbor, Michigan 48019, USA.*

Based on their experience with seating adults with SCI, the authors described optimal seating systems, identify common seating problems in relationship to level of SCI and offer some practical solutions. They emphasized that optimal seating systems achieve good pelvic alignment and a solid base of support. Correct positioning of the lower extremities, the trunk, the shoulder girdles and the head can then follow. A balance must be achieved between ease of positioning, transfers into and out of the system, skin protection, comfort and function. Common seating problems are related to level of SCI and include the increasing need for support of body parts with higher levels of injury, and the development of increased and asymmetrical muscle tone. By applying principles of seating to adults with SCI, improved comfort, appearance and function can be achieved. Prevention of deformities and other long-term seating problems result.

### **Freedom on the river program**

K. A. Shuerwood, BS, OTR, W. Waring, MD

*University of Michigan Medical Center, 1500 East Medical Center Drive, Room 1G225, Box 0046, Ann Arbor, Michigan 48109, USA.*

The authors describe a community based recreational rowing programme at the University of Michigan, 'Freedom on the River' in which over 20 individuals have

participated over the past 5 years. Paraplegics and quadriplegics as high as the C5 level have been able to participate in recreational or competitive rowing with adaptations such as specialized rowing craft, seating adaptations, specialized hand orthoses, and skulling oar adjustments. Benefits to programme participants have included increased upper body strength, increased level of cardiovascular fitness and endurance as well as psychological and psychosocial benefits.

#### **Initial and long-term costs of spinal cord injury**

G. G. Whiteneck, PhD, R. R. Menter, MD, S. W. Charlifue, MA, C. A. Brooks, MSHA, S. J. Solnick, ART

*Craig Hospital, 3425 South Clarkson Street, Englewood, Colorado 80110, USA.*

The authors present an analysis of the initial rehabilitation and annual follow up care expenses for 186 patients in 1 of 5 selected groups who were seen at the Rocky Mountain Regional Spinal Injury System at Craig Hospital between 1974 and 1984. The 5 groups elected for investigation included:

1. Respirator dependent individuals who have complete injuries from C1–C4 (12 patients).
2. Respirator independent individuals with complete injuries from C1–C4 (53 patients).
3. Individuals with complete injuries at C6 (41 patients).
4. Individuals with complete injuries at T3–T4 (44 patients).
5. Individuals with complete injuries at T11 (36 patients).

A significant pattern of hospitalization expenses associated with injury level was found ranging from average hospitalization (acute and initial rehabilitation) expense of \$51,752 for low paraplegics to \$170,055 for respirator dependent high quadriplegics. Average annual follow up expenses also showed significant differences by level of injury with low paraplegics averaging \$7,699 of annual follow up expenses compared to \$63,663 annual follow up expenses for respirator dependent quadriplegics. The authors noted, however, that very large and highly skewed distributions of follow up expenses existed within each of the 5 patient categories.

#### **Suicide precautions in a rehabilitation setting**

K. Blake, BSN, CRRN, S. Buckelew, PhD, J. McMahon, RN

*Rusk Rehabilitation Center, University of Missouri-Columbia, Hospital and Clinics, Columbia, Missouri 65212, USA.*

The authors describe implementation of interdisciplinary guidelines to address three specific levels of suicide risk of patients at the Rusk Rehabilitation Centre at the University of Missouri. Patients who were not currently suicidal but had recently been a suicide risk or were considered 'volatile' were placed on Suicide Alert and will be allowed to participate fully in the rehabilitation program. Patients who verbalize suicidal plans and were able to contract with team psychologists that no suicidal action would be taken were placed on Suicide Observation which entailed close supervision and restriction of activities. Patients considered at extremely high risk for suicide were placed on Suicide Precaution and were transferred to a psychiatric unit as soon as possible. The responses to questionnaires distributed to the staff indicated a wide range of estimates of the numbers of patients at some suicidal risk and the appropriate action which should be taken. Implementation of this programme has been followed by an improvement in team satisfaction with the care of suicidal clients.

**Upper extremity reflex sympathetic dystrophy syndrome associated with acute traumatic myelopathy—report of 4 cases**

S. A. Cremer, MD, F. M. Maynard, MD, G. Davidoff, MD

*Department of Physical Medicine & Rehabilitation, University of Michigan Hospitals, 1500 East Medical Center Drive, Room UH1D204, Ann Arbor, Michigan 48109, USA.*

The authors described 4 cases of function limiting reflex sympathetic dystrophy syndrome associated with cervical spinal cord injury, and diagnosed by three phase bone scan. All the patients were treated at the University of Michigan between December 1985 and August of 1986. Two were males and 2 were females. Two were neurologically complete injuries resulting from gunshot wounds to the neck and 2 were incomplete injuries resulting from cervical hyperextension without fracture during a fall and a motor vehicular accident respectively. Primary symptoms were of hand pain and sensation of restricted finger movement. Findings on physical examination variously included distal upper extremity edema, decreased range of motion of the glenohumeral, metacarpophalangeal and interphalangeal joints, signs of vasomotor instability, atrophic skin and significant tactile defensiveness. Tenderness to palpation was noted in all cases in the MCP and IP joints and periarticular areas. The primary diagnostic problem was differentiating the other types of upper extremity pain including dysesthetic pain at the zone of injury and arthritic joint pain. Hand radiographs and three phase bone scans were obtained. In each case the three phase bone scans were abnormal for increased delayed phase uptake in the metacarpophalangeal joints and periarticular areas compatible with the diagnosis of reflex sympathetic dystrophy syndrome. Treatment consisted of active and passive range of motion programs, also included were oral steroids, TENS unit, splinting and serial casting and local desensitization. Objective measures of pain and joint contractures improved in all cases. Two patients had total relief of pain. The pain complaints persisted from four to fourteen weeks after the onset of treatment and were function limiting, causing prolonged rehabilitation hospitalization.

**Carpal tunnel syndrome in Paraplegics**

H. Gellman, MD, D. R. Chandler, MD, J. Petrusek, MD, E. Sie, RPT, R. Waters, MD

*Department of Orthopaedics, 7601 East Imperial Highway, HB 138, Downey, California 90242, USA*

Because of the greater demands on the upper extremities that are necessary in the paraplegic population, the carpal tunnel syndrome has a higher prevalence than in the overall population. The authors undertook the study to distinguish whether the carpal tunnel syndrome of paraplegics resulted from increased carpal tunnel pressures or was due to repetitive trauma to the median nerve in the presence of normal carpal tunnel pressures. Seventy one paraplegics with an injury below T2 were evaluated for the signs and symptoms of the carpal tunnel syndrome. They were examined for thenar atrophy, Tinel's sign, and Phalen's sign. Volunteer patients underwent measurement of wrist range of motion, carpal tunnel x-ray, median nerve conduction testing and carpal tunnel pressure measurement. There were 10 wrists in 8 carpal tunnel pressure measurements. There were 10 wrists in 8 carpal tunnel syndrome paraplegics and 10 wrists in 10 non carpal tunnel syndrome paraplegics. The diagnosis of carpal tunnel syndrome was based on electrical and clinical criteria.

Results indicated that sensibility evaluation was found to be abnormal in 7 of 10 patients with symptoms of carpal tunnel syndrome. All asymptomatic patients had normal sensibility tests. Wrist range of motion did not differ greatly from norms for able-bodied. All paraplegics with a diagnosis of carpal tunnel syndrome met neurodiagnostic criteria for carpal tunnel syndrome with median sensory latency of 3.5 milliseconds or greater and an average amplitude of 22 microvolts or less. Carpal tunnel pressure in natural wrist position averaged 12 mm of mercury pressure in paraplegics with carpal tunnel syndrome and 8 mm of mercury pressure in paraplegics without

carpal tunnel syndrome. Pressures in full active flexion average 95 mm of mercury for carpal tunnel syndrome paraplegics and 42 mm for non carpal tunnel paraplegics. Pressures in full active extension averaged 160 mm of mercury for carpal tunnel syndrome paraplegics and 220 mm of mercury pressure for carpal tunnel syndrome paraplegics and 180 for non carpal tunnel syndrome paraplegics. The authors concluded that: (1) 'Paraplegics have an elevated baseline carpal tunnel pressure which may have contributed to their increased incidence of carpal tunnel syndrome. (2) The magnitude of the pressures measured in paraplegics at the extremes of wrist motion and during raises exceeds reported nerve viability threshold values and may contribute to the high incidence of carpal tunnel syndrome.'

### **The paraplegic hand: electrodiagnostic studies and clinical findings**

C. G. Tun, MD, J. Upton, MD

*Division of Plastic Surgery, The Children's Hospital, 300 Longwood Avenue, Boston, Massachusetts 02115, USA.*

The authors reviewed sixth paraplegic wheelchair dependent patients with a neurologic level below T1. Patients were selected at random, all being males ranging in age from 25 to 72 years. If a patient had a history of disease associated with peripheral neuropathy or with a history of acute hand injury, he was excluded. Patients were divided into 2 groups: those with less than 20 years paralysis and those with more than 20 years of paralysis. The following studies were carried out: (1) DAISA electromyograph was used for electrophysiologic measurements. (2) The motor, median and ulnar nerves of both hands were stimulated across the wrist using standard equipment. (3) Skin temperature was recorded at the mid flexor wrist crease with a surface probe. (4) Distal motor latency greater than 4.5 msec for the median and 3.5 msec for the ulnar nerve was considered abnormal.

Of the 240 median and ulnar nerves studied in 60 patients, 56 nerves (23%) were found to be abnormal in 30 patients. There were 31 abnormal median and 25 abnormal ulnar conduction times. The number of abnormal times was equal in the 2 groups studied. The ages were also similar. The mean temperature for patients with abnormal conduction times was 32° C in contrast to the mean temperature of 32.9° C for patients with normal studies. Only 9 of 46 hands with abnormal nerve conduction studies were reported to have numbness while 37% had joint pain and 44% were asymptomatic.

The authors concluded that the incidence and severity of abnormal electrodiagnostic findings was not associated with the duration of paralysis. The number of paraplegics with clinical findings suggested that peripheral nerve entrapment neuropathy is small and is similar to that reported for non paraplegic patients. Surgery has been reserved for symptomatic patients with abnormal conduction times.

Protective gloves with rubber palmar surface may prevent further nerve damage.

### **Shoulder pain and functional disability in spinal cord injury patients**

J. P. Silfverskiold, MD, R. L. Waters, MD

*Rancho Los Amigos Medical Center, 7601 East Imperial Highway, Downey, California 90242, USA.*

Sixty SCI patients were evaluated to determine the incidence of non-traumatic shoulder pain and associated functional disability during the first 18 months following injury. In the first 6 months following injury, 78% of the quadriplegics (31 of 40 cases) and 35% of the paraplegics (7 of 20 patients) had shoulder pain. When examined 6 to 18 months post injury the incidence of shoulder pain decreased to 33% for quadriplegics and 10% for paraplegics.

Functional disability was evaluated in the categories of proning, self-care, feeding, hygiene, bowel and bladder care, wheelchair propulsion and transfers. Disability was

graded depending on whether pain interfered with function as follows: mild, some discomfort while performing functional activities; moderate, discomfort sufficient to intermittently limit functional activities; severe, pain required stopping two or more functional activities. Pain did not result in moderate or severe disability in paraplegic patients. Functional disability was a significant problem for the quadriplegic patients. Twenty-nine quadriplegics had moderate or severe disability in the first 6 months following injury. Thirteen patients had moderate or severe disability at 6 to 18 months follow up. Spasticity increased the likelihood of shoulder pain in quadriplegics. Common etiologies and patterns of shoulder pain are described.

### **The Neil Squire Foundation Computer Comfort Program for the high lesion quadriplegics and other severely physically disabled adults**

S. Hornstein, BSc(PT), J. E. Steer, MSc, K. McKay, OT(C), M. Hurley, BSc, W. M. Cameron, BSc

*Neil Squire Foundation, 451-810 West Broadway, Vancouver, BC V5Z 4C9, Canada.*

Computer Comfort is a Canada-wide computer familiarization program operating in more than 50 hospitals, centres and private homes, with university co-op students as the instructors. The objective is to introduce technology as a means of increasing independence for adults who are severely physically disabled. One thousand five hundred people were enrolled in the first 2 years. The majority of this group required alternate methods of computer input for efficient use. Sip 'n puff morse code is the most common alternate input used by quadriplegics at the C4 level and above. Voice recognition is becoming a popular supplementary input method.

A preliminary survey indicated that of the 500 disabled students in the program sample, 342 had never seen a computer before. Two hundred seventy eight learned word processing skills and 358 received instruction for computer and personal education and/or business applications. Telecommunications via modem was not included in this survey, but was a popular skill being taught.

Computer Comfort has shown to be an effective means of introducing technology to disabled individuals and the rehabilitation professionals working in this field.

### **Biofeedback to facilitate ventilations in high quadriplegia: a case study**

S. A. Morrison, PT

*Physical Therapy Department, Shepherd Spinal Center, 2020 Peachtree Road NW, Atlanta, Georgia 30309, USA.*

A case study of the use of EMG feedback in the training of respiratory accessory muscles in a high quadriplegic is presented. The subject of the study is a 30 year old C-1 complete quadriplegic who at the initiation of the study had achieved fair muscle grades in the sternomastoid and upper trapezius musculature. EMG feedback was utilized placing active electrodes bilaterally over these muscles with both visual and auditory feedback. Utilizing this technique, the patient was able to improve from no measurable vital capacity at the beginning of the study to a vital capacity of 500 ccs and achieved 35 minutes off the ventilator. After the discontinuation of biofeedback, the patient was able to maintain a 55 cc vital capacity and sustained for an average of 7.5 minutes off the ventilator. The author concludes that this technique may be beneficial for high quadriplegic individuals, assisting them to become less dependent on the ventilator with the use of accessory musculature breathing.

**Management of communication problems in the patient with spinal cord dysfunction**

E. Ledwon-Robinson, MS, CCC, K. Kluin, MS, CCC, M. Berger, MS, CCC, A. Van Meter, MS, CCC, B. Hall, MS, CCC

*Department of Physical Medicine and Rehabilitation, University of Michigan Medical Center, 1500 East Medical Center Drive, Ann Arbor, Michigan 48109, USA.*

The results of a 5 year study including 58 patients with spinal cord injury at the University of Michigan Hospitals is reported. A three phase model of intervention was proposed. The first step, Staged Assessment, included a communicative screen to establish a reliable yes/no system and to evaluate the potential for verbal communication. The second phase is described as the Evolution of Communicative Intervention which focuses on tracheostomy tube selection, maintenance and problem solving. Most patients use 'mouthing' of words as a means to communicate but it is noted that 58% of all subjects use more than one communicative method with the most frequently occurring combination being the Portex 'talking' trache and electro larynx. The final phase was that of Evaluation of Intervention Efficacy which was assessed utilizing a six point scale of communication effectiveness:

1. Unable to communicate.
2. Limited to yes/no.
3. Conveys basic needs inconsistently and depends on others to elicit information.
4. Communicates with familiar listeners.
5. Effective communication but dependent on listener for mechanical assistance.
6. Effective communication with all listeners.

On initial contact, patients obtained a mean rating of 3.14. Ventilator dependent patients generally at level 3 or lower. At discharge, the mean rating for patients was 5.05 with ventilator dependent patients distributed heavily at 4.05. Overall, 67% of the total population received a rating of 5 by discharge. Ninety-six per cent of patients discharged with a tracheostomy tube were verbal communicators.