



## **Pediatric Spinal Cord Injury**

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*"I have heard about a young boy (4 or 5 years old) in hungary with a serious spinal cord injury eight months ago: as of my information, his spinal cord has broken between his skull and C1 totally (he is ventilator-dependent). What kind of therapies do you think, are suitable a person like him? Can we hope in some research that will help him to improve his condition? Are there any special problems in his care besides the usual important things like bladder and skin care to take attention? Thanks in advance. I will not give up the hope too!" – Message from a CareCure Reader (8 May 2003)*

I just received the above message. In answer, I wrote the following literature review of the emergency care, acute complications, chronic complications, and functional recovery in children with spinal cord injury. The abstracts of the cited papers are included because they indicate clinical centers that are experienced in pediatric spinal cord injury care.

Neurological injury represent 18% of pediatric injuries and accounted for 23% of pediatric traumatic deaths (Durkin, et al., 1998). However, spinal cord injury in young children is rare (Reynolds, 2000; Viccellio, et al., 2001), accounting for only 5% of spinal cord injuries (Apple, et al., 1995; Proctor, 2002). Spinal cord injury in children under 5 years are even more rare (Partrick, et al., 2000). This low incidence may be due to the flexibility of the young spinal column (Boockvar, et al., 2001) Nearly 80% of injuries in children less than 2 years old involve the C1-C2 cervical segments (Kokoska, et al., 2001; Sun, et al., 2000). By 8 years, the pattern begins to approach adult patterns.

## Emergency Care

The first and most important step in the emergency care of children with spinal cord injury is stabilization of the spine, to prevent further damage to the spinal cord. Care should be taken to use pediatric head boards that have an opening for the head so that there is no neck flexion due to the larger heads of children placed supine on the board (2002). A high degree of suspicion for cervical spinal cord injury is warranted in children with sporting injuries or signs of abuse (Brown, et al., 2001).

Surgical approaches to children with spinal cord injury differ from those of adults (Eleraky, et al., 2000; Lalonde, et al., 2001). Most of the time, because the injuries are to the upper cervical spine, closed reduction and halo immobilization are recommended for children younger than 8 years of age. However, posterior occipitovertebral fusions are usually necessary for atlanto-occipital dislocation (Kenter, et al., 2001; Rekate, et al., 1999; Shamoun, et al., 1999). Use of posterior instrumentation, such as the posterior screw, as well as internal fixation, is feasible (Rekate, et al., 1999). Transoral approaches for anterior decompression of the craniovertebral junction may be associated with long-term swallowing and speech difficulties (Tuite, et al., 1996).

Although there has not been any formal clinical trial assessing the effects of methylprednisolone for pediatric spinal cord injury, this is the standard therapy for adult spinal cord injury. In my opinion, children should also receive the high dose methylprednisolone treatment (30 mg/kg i.v. bolus within 8 hours followed by 5.4 mg/kg/hour for 24 hours). High dose methylprednisolone is frequently given to children and appears to be well-tolerated with little side-effects (Alehan, et al., 2002; Ancona, et al., 2002; Defresne, et al., 2001; Hicsonmez, et al., 2001; Matsui, et al., 2002; Shahar, et al., 2002; Sundel, 2002; Tenembaum, et al., 2002; Tunc, et al., 2003; Yetgin, et al., 2003).

The major goal of initial medical management for children with high cervical injuries is to wean them off the respirator if possible. A majority of children with cervical spinal cord injuries can be weaned off their respirators. A recent study from the Alfred I. duPont Hospital in Wilmington Delaware (Padman, et al., 2003) described a 20-year experience with managing tracheostomy and ventilator-dependent children. Many had concomitant brain injury and 52% had C1-C2 injuries while the remainder had C3-C5. However, they were able to successfully wean 63% of the patients from their respirators.

## Acute Complications

The acute physical care of children with spinal cord injury is similar to adult care. Bowel and bladder care, skin care to prevent decubiti ulcers, physical therapy to prevent atrophy and contractures, and careful pulmonary care prevent devastating complications that can reduce or even reverse neurological recovery. Note that young children, particularly those with head injuries and those on ventilators, may have low potassium levels (hypokalemia) that often predicts longer hospitalization times and longer ventilation times (Beal, et al., 2002).

Children with spinal cord injury tend to get autonomic dysreflexia (AD), a condition where blood pressure may go up to high levels (Hickey & Vogel, 2002). Sometimes, they can show self-injurious behavior (Vogel & Anderson, 2002) which may be a manifestation of dysesthesia or neuropathic pain and sometimes can be resolved with anti-convulsant therapies that may relieve such pain and psychological management (Colville & Mok, 2003).

Urinary tract infections and bladder spasticity are also common. In very young children, a suprapubic catheter may be more convenient and a mitrofanoff procedure (Ellsworth, et al., 1996; Hakenberg, et al., 2001; Sylora, et al., 1997) may be considered to provide independent access to the bladder. Older children can use sterile catheterization techniques (Van Hala, et al., 1997).

Although traumatic patients have predisposing risk factors for deep vein thromboses (DVT) or clots in the leg, DVT's are very rare in the general pediatric trauma population. One study of 2746 pediatric traumatic patients (Grandas, et al., 2000) observed DVT in only 3 patients, suggesting that routine screening or prophylaxis is not indicated except for patients who remain immobile for extended periods, require prolonged rehabilitation, or have venous manipulations. Another study of 532 patients found a 2.2% overall incidence of DVT but those with spinal cord injury had 10% incidence (Radecki & Gaebler-Spira, 1994).

From a psychological point of view, children are not “small adults” (Merenda, 2001) and require different psychological and social support that is probably best provided at centers specialized for care of children (Betz, 1997; Mulcahey, 1997). Psychological and adaptive responses to spinal cord injury may also differ (Sammallahti, et al., 1996). In adolescents, cosmetic appearance may play an important role in acceptance of certain treatments. The approach should incorporate the child's age, development level, and family (Keen, 1990).

## Chronic Complications

Vogel, et al. (Vogel, et al., 2002b) studied the complications of spinal cord injury of 216 adults who had had spinal cord injury at 18 years or younger. They had all the usual complications of spinal cord injury, including pressure ulcers (decubiti), urinary tract infections, and spasticity. Severe urinary tract infections and pressure ulcers, pain, and respiratory complications markedly influenced life satisfaction (Vogel, et al., 2002a). Many of these complications contribute to low employment rates (Anderson & Vogel, 2002) and low life satisfaction (Anderson, et al., 2002; Kannisto & Sintonen, 1997).

Musculoskeletal problems are frequent in people who suffered spinal cord injury as children. According to Vogel, et al. (Vogel, et al., 2002c), the most common complaint was pain (69%), spasticity (57%), shoulder pain (48%), scoliosis (40%), hip contractures (23%), and back pain (22%). These rates of complications did not depend on gender. Younger age at injury were associated with higher rates of scoliosis and hip subluxation. Older ages were associated with more ankle pain and spasticity. Bone density is usually grossly decreased in the femoral region and caution should be observed in weight bearing training (Kannisto, et al., 1998a; Moynahan, et al., 1996a).

Scoliosis is a common and serious complication of pediatric spinal cord injury. Of 130 patients who were injured before and after the adolescent growth spurt, scoliosis developed in 97% and 52% respectively. Bracing was effective in delaying the curve progression in the preadolescent group (Dearolf, et al., 1990).

In kids who cannot be weaned off the ventilator, phrenic nerve stimulation should be considered (Giglio, et al., 2002). Abnormally increased sweating (hyperhidrosis) sometimes can occur in children after spinal cord injury and can be treated with gabapentin (Adams, et al., 2002). Artificial urinary sphincters may be useful for some patients (Holmes, et al., 2001). Surgical procedures can be considered to reduce urinary incontinence (Austin, et al., 2001). Most females who were injured before menarche showed normal onset of menarche with no significant menstrual problems (Anderson, et al., 1997).

The Shriner's Hospitals (McCollough, 2000) for Children in Philadelphia has a long-standing program of upper and lower extremity stimulation in children (Bonaroti, et al., 1999; Moynahan, et al., 1996b; Mulcahey, et al., 1997; Partrick, et al., 2000; Smith, et al., 2001; Triolo, et al., 1994) to reduce atrophy and to promote independence. Children may benefit from earlier implantation of devices (Johnston, et al., 2003).

## Recovery

In young children, spinal cord injury without radiographic abnormalities (SCIWORA) can occur, accounting for as many as 32% of the spinal cord injuries and tended to be severe, i.e. 70% were “complete”, and traditionally associated with a “grim prognosis” (Pang & Wilberger, 1982). In contrast, in children over 12 years old, it occurred in only 12% of patients, was rarely associated with “complete” spinal cord injury, and they have an excellent prognosis for complete recovery of neurological function (Dickman, et al., 1991). As with other types of spinal cord injury, kids with complete neurological lesions tend to have a poorer prognosis for recovery than those with some neurological function below the injury site (Hamilton & Myles, 1992). However, in another study, as many as 20% of pediatric patients with “complete” myelopathy had evidence of significant functional recovery (Hadley, et al., 1988). More recent studies, using more stringent radiological criteria, however, suggest that SCIWORA is very rare (Bosch, et al., 2002).

The patterns of recovery of children tend to follow those of adults but may be more variable (Garcia, et al., 2002). Thus, for example, children with “incomplete” spinal cord injuries tend to recover more than those with “complete” loss of neurological function below in the injury site at the time of admission (Turgut, et al., 1996). The degree of recover does not appear to be significantly related to age, sex, length of inpatient rehabilitation, or cause of injury. Recovery of household ambulation is common (Vogel & Lubicky, 1995a; b). In general, children with C1 through C7 injuries have a high likelihood of achieving reasonable independent functioning (Partrick, et al., 2000).

People with pediatric spinal cord injury tend to assign lower priority to self-mobility and have the higher level of health-related quality of life (Kannisto, et al., 1998b) than people who were injured as adults. Like adults, however, pediatric tetraplegics have lower satisfaction ratings than paraplegics. Several studies suggest that people with pediatric spinal cord injury have the greatest opportunity for a satisfying adult life if rehabilitation emphasizes psychosocial factors such as education, employment, and long-term health management (Vogel, et al., 1998).

Children with spinal cord injury also tend to do well in school. For example, an analysis of 144 people who had pediatric spinal cord injury in Seattle (Massagli, et al., 1996) showed that above average student participation and performance compared to peers; 84% of those in secondary schools planned to attend college and 91% graduated from high school. About 71% of college graduates held jobs and 36% of the people surveyed were in college.

## Literature Cited

- (2002). Management of pediatric cervical spine and spinal cord injuries. *Neurosurgery* 50:S85–99. Summary: DIAGNOSTIC: Standards: There is insufficient evidence to support diagnostic standards. Guidelines: In children who have experienced trauma and are alert, conversant, have no neurological deficit, no midline cervical tenderness, and no painful distracting injury, and are not intoxicated, cervical spine x-rays are not necessary to exclude cervical spine injury and are not recommended. In children who have experienced trauma and who are either not alert, nonconversant, or have neurological deficit, midline cervical tenderness, or painful distracting injury, or are intoxicated, it is recommended that anteroposterior and lateral cervical spine x-rays be obtained. Options: In children younger than age 9 years who have experienced trauma, and who are nonconversant or have an altered mental status, a neurological deficit, neck pain, or a painful distracting injury, are intoxicated, or have unexplained hypotension, it is recommended that anteroposterior and lateral cervical spine x-rays be obtained. In children age 9 years or older who have experienced trauma, and who are nonconversant or have an altered mental status, a neurological deficit, neck pain, or a painful distracting injury, are intoxicated, or have unexplained hypotension, it is recommended that anteroposterior, lateral, and open-mouth cervical spine x-rays be obtained. Computed tomographic scanning with attention to the suspected level of neurological injury to exclude occult fractures or to evaluate regions not seen adequately on plain x-rays is recommended. Flexion/extension cervical x-rays or fluoroscopy may be considered to exclude gross ligamentous instability when there remains a suspicion of cervical spine instability after static x-rays are obtained. Magnetic resonance imaging of the cervical spine may be considered to exclude cord or nerve root compression, evaluate ligamentous integrity, or provide information regarding neurological prognosis. TREATMENT: Standards: There is insufficient evidence to support treatment standards. Guidelines: There is insufficient evidence to support treatment guidelines. Options: Thoracic elevation or an occipital recess to prevent flexion of the head and neck when restrained supine on an otherwise flat backboard may allow for better neutral alignment and immobilization of the cervical spine in children younger than 8 years because of the relatively large head in these younger children and is recommended. Closed reduction and halo immobilization for injuries of the C2 synchondrosis between the body and odontoid is recommended in children younger than 7 years. Consideration of primary operative therapy is recommended for isolated ligamentous injuries of the cervical spine with associated deformity.

- Adams BB, Vargus–Adams JN, Franz DN and Kinnett DG (2002). Hyperhidrosis in pediatric spinal cord injury: a case report and gabapentin therapy. *J Am Acad Dermatol* **46**:444–6. Summary: Hyperhidrosis is a relatively common condition with a multitude of causes. Spinal cord injury may be complicated by hyperhidrosis. Many forms of therapy have been reported for this phenomenon but few have been demonstrated to be efficacious. We describe a case of a child with hyperhidrosis from a spinal cord injury and report the first therapeutic use, to our knowledge, of gabapentin for hyperhidrosis. Department of Dermatology, College of Medicine, University of Cincinnati, PO Box 670592, Cincinnati, OH 45267–0592, USA. adamsbb@email.uc.edu
- Alehan FK, Boyvat F, Baskin E, Derbent M and Ozbek N (2002). Focal cerebral vasculitis and stroke after chickenpox. *Eur J Paediatr Neurol* **6**:331–3. Summary: Cerebral infarcts are rather rare in children and can be caused by a number of diverse conditions. We report a case of cerebral infarct associated with a recent varicella infection. A 5–year old girl presented with an acute central facial palsy 1 month after a chickenpox infection. The infarction was revealed by magnetic resonance imaging and laboratory studies ruled out all known causes of stroke. Cerebral angiogram demonstrated segmental narrowing and irregularity of the wall of the right internal carotid artery, compatible with focal vasculitis. With the presumed diagnosis of varicella–associated focal angiitis, the patient was treated with high–dose methylprednisolone, acyclovir and aspirin. Magnetic resonance angiogram performed 6 weeks after the stroke demonstrated the resolution of the vasculitis. Varicella infection should be considered one of the possible causes of acute ischaemic strokes in children. Department of Paediatrics, Baskent University, Ankara, Turkey. falehan@hotmail.com
- Ancona KG, Parker RI, Atlas MP and Prakash D (2002). Randomized trial of high–dose methylprednisolone versus intravenous immunoglobulin for the treatment of acute idiopathic thrombocytopenic purpura in children. *J Pediatr Hematol Oncol* **24**:540–4. Summary: BACKGROUND: Idiopathic thrombocytopenic purpura (ITP) is an acquired disorder characterized by immune–mediated platelet destruction. The authors performed a prospective, randomized trial comparing intravenous immunoglobulin (IVIg) with high–dose intravenous methylprednisolone in the treatment of children with acute ITP. The primary aim of the study was to compare the rate of platelet increase produced by either intervention. A decision to treat was based on the clinical presentation and not an arbitrary platelet count. In general, enrolled patients exhibited extensive bruising and platelet counts less than  $10 \times 10^9 /L$  (10,000/microL). PATIENTS AND METHODS: Seventy–seven consecutive patients, for whom the attending hematologist determined acute treatment was warranted, were studied.

Forty-two patients received IVIG (1 g/kg/dose x2) and 35 received methylprednisolone (30 mg/kg/dose x3). Patients who exhibited an increase in platelet count of more than 50,000/microL after the first IVIG dose or the second methylprednisolone dose did not receive the second IVIG dose or the third methylprednisolone dose, respectively. Patients' ages ranged from 6 months to 15 years. Platelet counts were evaluated at presentation, 24, 48, 72 hours, 1 week, and 2 to 4 weeks. RESULTS: Eighty percent of patients treated with IVIG and 60% of patients treated with methylprednisolone demonstrated an increase in platelet count of 50,000/microL or more within 48 hours. Both IVIG and methylprednisolone therapy increased platelet counts significantly above pretreatment values. In the methylprednisolone group, the mean baseline platelet count was 4,600/microL, which rose to 14,000/microL after 24 hours, 38,000/microL after 48 hours, and 65,000/microL after 72 hours. The IVIG group had a mean baseline platelet count of 4,200/microL, which rose to 32,000/microL after 24 hours, 69,000/microL after 48 hours, and 146,000/microL after 72 hours. When compared with methylprednisolone, IVIG therapy produced a greater rise in platelet counts at 24, 48, and 72 hours, with no difference at 1 week or later time points. No serious bleeding was noted in either treatment group. CONCLUSIONS: Both IVIG and methylprednisolone produce a significant early rise in platelet count that is somewhat greater with IVIG. However, the higher platelet counts produced by IVIG may not justify the additional cost and potential risks of this agent. Department of Pediatrics, SUNY–Stony Brook, New York 11794, USA.

- Anderson CJ, Krajci KA and Vogel LC (2002). Life satisfaction in adults with pediatric-onset spinal cord injuries. *J Spinal Cord Med* 25:184–90. Summary: OBJECTIVE: To determine the level of life satisfaction of adults with pediatric-onset spinal cord injuries (SCI) and the factors associated with life satisfaction. METHOD: A structured interview including standardized measures. PARTICIPANTS: Participants were individuals who sustained SCI at age 18 years or younger, were 24 years of age or older at interview, did not have significant brain injury, and were living in the United States or Canada. OUTCOME MEASURES: A structured interview, the Functional Independence Measure (FIM), the Craig Handicap Assessment and Reporting Technique (CHART), the Short-Form 12 (SF-12), and the Satisfaction with Life Scale (SWLS). Results: Two hundred sixteen individuals were interviewed. Mean age at injury was 14 years, mean age at interview was 29 years, and mean duration of injury was 14 years. The mean SWLS score was 23.6, and the median score was 25. There was not a significant difference between men and women, but those with tetraplegia were significantly less satisfied than were those with paraplegia. A regression model identified age at injury, community mobility (CHART), marital status, use of street drugs, perceived mental



health (SF-12), and medical complications as predictors of life satisfaction. Other factors strongly associated with SWLS were employment, income, independent living, FIM total plus physical and sociocognitive domain scores, perceived physical health (SF-12), and CHART total plus the subscales of physical independence, cognitive independence, and occupation. Conclusions: Life satisfaction in adults with pediatric-onset SCI is associated with demographic, injury-related, and functional limitation factors, as well as with health status and community integration outcomes. Shriners Hospital for Children, Chicago, Illinois, USA. canderson@shrinenet.org

- Anderson CJ, Mulcahey MJ and Vogel LC (1997). Menstruation and pediatric spinal cord injury. *J Spinal Cord Med* 20:56–9. Summary: Menstrual characteristics were studied in young women who sustained spinal cord injuries (SCI) prior to puberty or in early adolescence. Subjects were 37 females who were injured prior to age 16 years and who were at least 10 years old at the time of interview; 22 were injured prior to menarche and 15 after menarche. Average age of menarche for females injured before puberty was 12.3 years which is similar to their mothers (mean 12.6 years) and to patients injured after menarche (mean 12.0 years). Of 15 females injured after menarche, seven reported no interruption in menses while eight had interruptions ranging from one to seven months. No significant menstrual problems were noted in either group. This information about menstruation should be included in sexuality teaching of parents and patients when an SCI occurs to a child or adolescent. Shriners Hospitals, Chicago Unit, IL 60707, USA.
- Anderson CJ and Vogel LC (2002). Employment outcomes of adults who sustained spinal cord injuries as children or adolescents. *Arch Phys Med Rehabil* 83:791–801. Summary: OBJECTIVES: To determine employment outcomes of adults with pediatric-onset spinal cord injury (SCI) and factors associated with those outcomes. DESIGN: Structured interview, including standardized measures. SETTING: Community. PARTICIPANTS: Individuals who sustained an SCI at age 18 years or younger, were 24 years or older at follow-up, did not have a significant brain injury, and were living in the United States or Canada. A total of 195 subjects were interviewed. Mean age at injury was 14 years (0–18 y), mean age at interview was 29 years (24–37 y), and mean duration of injury was 15 years (7–28 y). All participants had been enrolled in SCI programs. INTERVENTIONS: Not applicable. MAIN OUTCOME MEASURES: A structured interview, the FIM instrument, the Craig Handicap Assessment and Recording Technique, the Medical Outcomes Study 12-Item Short-Form Health Survey, and the Satisfaction with Life Scale. RESULTS: Of the participants, 99 (51%) were employed, 78 (40%) were unemployed, 12 (6%) were students, and 6 (3%) were homemakers. A predictive model of

employment identified 4 factors associated with employment: education, community mobility, functional independence, and decreased medical complications. Other variables significantly associated with employment included community integration, independent driving, independent living, higher income, and life satisfaction. CONCLUSIONS: Compared with the general population, the high rate of unemployment among adults with pediatric-onset SCI is a cause for concern. Risk factors associated with adult unemployment provide guidelines for targeting rehabilitation resources and strategies. Shriners Hospital for Children, Chicago, IL 60707, USA. canderson@shrinenet.org

- Apple DF, Jr., Anson CA, Hunter JD and Bell RB (1995). Spinal cord injury in youth. *Clin Pediatr (Phila)* **34**:90–5. Summary: To identify special characteristics of the pediatric spinal cord-injured (SCI) population, we analyzed a database of 1,770 traumatic SCI patients; 88 (5%) fell into the two pediatric subgroups: 0–12 years (n = 26) and 13–15 years (n = 62) at time of injury. Differences between age groups were identified with regard to demographics, neurologic characteristics, associated injuries and complications, and management. Mode level of bony injury was C2 in preteens, C4 in teens, and C4–C5 in adults. Scoliosis developed far more frequently in children, particularly preteens (23%), than in adults (5%). Violent etiologies, predominantly gunshots, accounted for a disproportionate share of injuries to preteens (19%) and African-Americans (28%), as compared with adults (12%) and Caucasians (7%). This last finding underscores the urgent need to mount a response to the nationwide proliferation of gunshot-related SCI in children and minorities. Clinical Research Department, Shepherd Spinal Center, Atlanta, Georgia 30309, USA.

- Austin PF, Westney OL, Leng WW, McGuire EJ and Ritchey ML (2001). Advantages of rectus fascial slings for urinary incontinence in children with neuropathic bladders. *J Urol* **165**:2369–71; discussion 2371–2. Summary: PURPOSE: Many surgical procedures to improve outlet resistance in children with neuropathic bladders are obstructive and increase the detrusor leak point pressure. In contrast, fascial slings are designed to achieve continence by increasing the Valsalva or stress leak point pressure without altering the detrusor leak point pressure. We evaluate the effectiveness of fascial slings in achieving continence in pediatric patients with neuropathic bladder. MATERIALS AND METHODS: From October 1994 until February 1999, 10 females and 8 males with neuropathic bladder secondary to myelodysplasia or traumatic spinal cord injury underwent fascial sling procedures. Mean patient age was 14 years (range 8 to 18) and all were incontinent despite aggressive medical management. Urodynamic evaluation was performed preoperatively and postoperatively. Specific urodynamic measurements included detrusor

leak point pressure, stress leak point pressure and detrusor compliance. Compliance was only compared in the 12 nonaugmented cases. RESULTS: With a mean followup of 21.2 months (range 6 to 57), preoperative and postoperative urodynamics revealed little change in mean detrusor leak point pressure (23.2 versus 23.22 cm. H<sub>2</sub>O) but a substantial increase in mean stress leak point pressure (41.6 versus 64.5 cm. H<sub>2</sub>O). Mean compliance was unchanged in the nonaugmented group (22.00 versus 26.78 ml/cm. H<sub>2</sub>O). Four patients (22.22%) remained wet after surgery, of whom 2 were successfully treated with a repeat sling procedure and 1 with collagen injection for an overall continence rate of 94.44%. CONCLUSIONS: Fascial slings can be effectively used in pediatric patients for neuropathic incontinence. Furthermore, stress urinary incontinence is corrected by increasing the Valsalva or stress leak point pressure with preservation of the detrusor leak point pressure. Preservation of detrusor leak point pressure is particularly advantageous because other forms of bladder outlet procedures achieve continence at the expense of increasing detrusor pressures, thus placing the upper tracts at risk for damage. Division of Urology, University of Texas, Houston Medical School, Texas, USA.

- Beal AL, Scheltema KE, Beilman GJ and Deuser WE (2002). Hypokalemia following trauma. *Shock* **18**:107–10. Summary: Frequent hypokalemia was noted immediately after trauma, and it was hypothesized that hypokalemia occurred more frequently in the more severely injured. A retrospective trauma registry and chart review was done on 546 trauma patients looking at admission potassium, a variety of lab tests related to potassium, specific injuries, hospital/ICU lengths of stay, and general patient demographics. Admission hypokalemia (K < 3.6 meq/l) was more frequent in those with closed head injuries (41.1% vs. 27.5%, P < .001) and in those who suffered spinal cord injuries (54.5% vs. 33.6%, P < .05). Hyperglycemia was more frequent with admission hypokalemia (45.2% vs. 29.7%, P < .001). Hypokalemia occurred more frequently in younger patients (28.6 vs. 37.7 y, P < .001). Also, the pediatric group, ages 5–14, had admission hypokalemia more frequently than those ages 15–59, or those ages > 59 (54.9% vs. 34.5% vs. 16.7%, P < .001). Glasgow Coma Scores (GCS) were significantly lower (12.0 vs. 13.5, P < .001) and Injury Severity Scores (ISS) were higher (17.4 vs. 13.4, P < .001), with admission hypokalemia. Additionally, hypokalemia was a positive predictor of ISS (P = .05). Hypokalemic patients more likely needed a ventilator, (26.6% vs. 16.5%, P < .01) but did not have significantly more ventilator days (P > .05). Subsequently, hypokalemic patients had longer ICU lengths of stay (LOS) (2.6 vs. 1.5 days, P < .005) and longer hospital LOS (8.5 vs. 5.6 days, P < .001). When stratified into categories of "severe": (K < 3.1 meq/l), "moderate": (K = 3.1–3.3 meq/l), and "mild": (K = 3.4–3.5 meq/l) hypokalemia, those with severe hypokalemia had significantly lower GCS

(10.0 vs. 13.1,  $p < .05$ ), higher serum glucose levels (167 vs. 137 mg/dl,  $P < .05$ ), lower creatinine levels (.77 vs. .95 mg/dl,  $P < .05$ ), and longer hospital lengths of stay (13.1 days vs. 7.6 days,  $P < .05$  results). North Memorial Health Care, Robbinsdale, Minnesota, 55422, USA.

- Betz RR (1997). Unique management needs of pediatric spinal cord injury patients: orthopedic problems in the child with spinal cord injury. *J Spinal Cord Med* **20**:14–6. Summary:

- Bonaroti D, Akers JM, Smith BT, Mulcahey MJ and Betz RR (1999). Comparison of functional electrical stimulation to long leg braces for upright mobility for children with complete thoracic level spinal injuries. *Arch Phys Med Rehabil* **80**:1047–53. Summary: OBJECTIVE: To prospectively compare functional electrical stimulation (FES) to long leg braces (LLB) as a means of upright mobility for children with motor-complete thoracic level spinal cord injuries (SCIs). DESIGN: Intrasubject group comparison of two interventions. SETTING: Nonprofit pediatric orthopedic rehabilitation facility specializing in SCI. PATIENTS OR OTHER PARTICIPANTS: Convenience sample of five children between 9 and 18 years old with motor-complete thoracic level SCI. The hip and knee extensors were excitable by electrical stimulation. INTERVENTIONS: The FES system consisted of percutaneous intramuscular electrodes implanted to the hip and knee extensors and a push-button activated stimulator worn about the waist. Standing was accomplished by simultaneous stimulation of all implanted muscles. For foot and ankle stability, either ankle-foot orthoses (AFO) or supramalleolar orthoses were used. The LLB system consisted of a custom knee-ankle foot orthosis (KAFO) for four subjects and a custom reciprocating gait orthosis (RGO) for one subject who required bracing at the hip. For both interventions, either a front-wheeled walker or Lofstrand crutches were used as assistive devices. Each subject was trained in the use of both FES and LLB in seven standardized upright mobility activities: stand and reach, high transfer, toilet transfer, floor to stand, 6-meter walk, stair ascent, and stair descent. MAIN OUTCOME MEASURES: For each mobility activity, five repeated measures of level of independence, using the 7-point Functional Independence Measure (FIM) scale, and time to completion were recorded for each intervention. Subjects were also asked which intervention they preferred. RESULTS: For 94% of comparisons, subjects required equal (70%) or less (24%) assistance using FES as compared with LLB. Six of the seven mobility activities required less time to complete using FES, two activities at significant levels. The FES system was preferred in 62% of the cases, LLB were desired 27% of the time, and there was no preference in 11% of the cases. CONCLUSIONS: The FES system generally provided equal or greater independence in seven mobility activities as compared with LLB, provided faster sit-to-stand times, and was preferred over LLB in a

majority of cases. Follow-up evaluations of both modes of upright mobility are needed to compare long-term performance and satisfaction. Research Department, Shriners Hospitals for Children, Philadelphia, PA 19140, USA.

- Boockvar JA, Durham SR and Sun PP (2001). Cervical spinal stenosis and sports-related cervical cord neurapraxia in children. *Spine* 26:2709–12; discussion 2713. Summary: STUDY DESIGN: Congenital spinal stenosis has been demonstrated to contribute to cervical cord neurapraxia after cervical spinal cord injury in adult athletes. A sagittal canal diameter <14 mm and/or a Torg ratio (sagittal diameter of the spinal canal: midcervical sagittal vertebral body diameter) of <0.8 are indicative of significant cervical spinal stenosis. Although sports-related cervical spine injuries are common in children, the role of congenital cervical stenosis in the etiology of these injuries remains unclear. OBJECTIVES: The authors measured the sagittal canal diameter and the Torg ratio in children presenting with cervical cord neurapraxia resulting from sports-related cervical spinal cord injuries to determine the presence of congenital spinal stenosis. METHODS: A total of 13 children (9 male, 4 female) presented with cervical cord neurapraxia after a sports-related cervical spinal cord injury. Age ranged from 7 to 15 years (mean +/- SD, 11.5 +/- 2.7 years). The sports involved were football (n = 4), wrestling (n = 2), hockey (n = 2), and soccer, gymnastics, baseball, kickball, and pogosticking (n = 1 each). Lateral cervical spine radiographs were used to determine the sagittal canal diameter and the Torg ratio at C4. RESULTS: The sagittal canal diameter (mean +/- SD, 17.58 +/- 1.63 mm) and the Torg ratio (mean +/- SD, 1.20 +/- 0.24) were normal in all of these children. CONCLUSION: Using the sagittal canal diameter and the Torg ratio as a measurement of congenital spinal stenosis, the authors did not find evidence of congenital cervical spinal stenosis in a group of children with sports-related cervical spinal cord neurapraxia. The occurrence of cervical cord neurapraxia in pediatric patients can be attributed to the mobility of the pediatric spine rather than to congenital cervical spinal stenosis. Division of Neurosurgery, Children's Hospital of Philadelphia and University of Pennsylvania Medical Center, USA. boockvar@hotmail.com

- Bosch PP, Vogt MT and Ward WT (2002). Pediatric spinal cord injury without radiographic abnormality (SCIWORA): the absence of occult instability and lack of indication for bracing. *Spine* 27:2788–800. Summary: STUDY DESIGN: A retrospective review of medical records and imaging studies of children diagnosed with spinal cord injury without radiographic abnormality (SCIWORA) or SCIWORA-like symptoms at Children's Hospital of Pittsburgh between 1965 and 1999 was undertaken. OBJECTIVES: To evaluate the existence of occult segmental

spinal instability and a role for bracing as treatment for SCIWORA, we contrasted the Children's Hospital of Pittsburgh experience with literature reports on SCIWORA. **SUMMARY OF BACKGROUND DATA:** There is a great deal of confusion and conflicting evidence regarding pediatric SCIWORA in the literature. Previous reports from our institution reported unique findings, including the only description of serious, recurrent SCIWORA in the literature. These findings have frequently been cited as the justification for long-term immobilization in all cases of SCIWORA.

**METHODS:** All records on patients coded as spinal cord injury without fracture or dislocation (ICD-9 code 952.xx) were reviewed. Children 17 years of age or younger with traumatic spinal cord injury and normal plain radiographic findings were included. Penetrating trauma, infection, or metabolic diseases were excluded. **RESULTS:** A total of 189 patients were diagnosed with SCIWORA at our institution over the 35-year review period. These patients differed from those reported in the literature with respect to a higher incidence, older age, less involved neurologic injury, and more low-energy mechanisms, such as sports and falls. There were no cases of a patient with SCIWORA who deteriorated and developed a permanent neurologic deficit after having either recovered or plateaued from an initial SCIWORA. All recurrent SCIWORA recovered to normal neurologic function. Bracing did not demonstrate any benefit in preventing these minor recurrent SCIWORAs. **CONCLUSION:** We identified no cases of serious, recurrent SCIWORA at our institution from 1965 to 1999. A case-by-case evaluation is required for the treatment of spinal cord injury without apparent spinal column injury, and bracing is not uniformly indicated. Department of Orthopaedic Surgery, University of Pittsburgh Medical Center, Children's Hospital of Pittsburgh, Pittsburgh, Pennsylvania, USA.

- Brown RL, Brunn MA and Garcia VF (2001). Cervical spine injuries in children: a review of 103 patients treated consecutively at a level 1 pediatric trauma center. *J Pediatr Surg* **36**:1107-14. **Summary:** **PURPOSE:** Cervical spine (C-spine) injuries occur infrequently in children but may be associated with significant disability and mortality. The purpose of this study was to review the experience of a level 1 pediatric trauma center to determine the epidemiology, risk factors, mechanisms, levels, types of injury, comorbid factors, and outcomes associated with these potentially devastating injuries. **METHODS:** A retrospective analysis of 103 consecutive C-spine injuries treated at a level 1 pediatric trauma center over a 9(1/2)-year period (January 1991 through August 2000) was performed. **RESULTS:** The mean age was 10.3 +/- 5.2 years, and the male-to-female ratio was 1.6:1. The most common mechanism of injury was motor vehicle related (52%), followed by sporting injuries (27%). Football injuries accounted for 29% of all sports-related injuries. Sixty-eight percent of all children sustained injuries to C1 to C4; 25% to C5 to

C7; and 7% to both. Spinal cord injury without radiographic abnormality (SCIWORA) occurred in 38%. Five patients had complete cord lesions involving the lower C–spine (C4 to C7); 4 of these were motor vehicle related, and all 4 patients died. Isolated C–spine injuries occurred in 43%, whereas 38% had associated closed head injuries (CHI). The overall mortality rate was 18.5%, most commonly motor vehicle related (95%), occurring in younger children (mean and median age 5 years) and associated with upper C–spine injuries (74%) and CHI (89%). C1 dislocations occurred in younger children (mean age, 6.6 years), most often as a result of motor vehicle–related trauma (especially pedestrians) and were associated with the highest injury severity score (ISS), longest length of stay (LOS), most CHIs, and the highest mortality rate (50%). C–spine fractures with or without SCI occurred most commonly as a result of falls and dives. Sporting injuries occurred almost exclusively in adolescent boys (mean age, 13.8 years) and were isolated injuries associated with a relatively low ISS and shorter LOS. Interestingly, 75% of sporting injuries showed SCIWORA, and all infants suffering from child abuse had SCIWORA. CONCLUSIONS: Mechanisms of injury are age related, with younger children sustaining C–spine injuries as a result of motor vehicle–related trauma and older adolescents commonly injured during sporting activities. C–spine injuries in children most commonly involve the upper C–spine, but complete lesions of the cord are associated more frequently with lower C–spine injuries. The type of C–spine injury is related to the mechanism of injury: SCIWORA is associated with sporting activities and child abuse, C–spine dislocations most commonly result from motor vehicle–related trauma (especially among pedestrians), and C–spine fractures occur most commonly as a result of falls and dives. Predictors of mortality include younger age, motor vehicle–related mechanism, C1 dislocations, high ISS greater than 25, and associated CHI. A high index of suspicion for SCIWORA is essential when evaluating adolescents with neck trauma associated with sporting injuries or victims of child abuse. Children's Hospital Medical Center, Division of Trauma Services, Cincinnati, OH 45229–3039, USA.

- Colville GA and Mok Q (2003). Psychological management of two cases of self injury on the paediatric intensive care unit. *Arch Dis Child* **88**:335–6. Summary: Self injury has not been previously reported in an intensive care setting. Two cases are presented of ventilator dependent children with high spinal cord lesions who exhibited an unusual form of self mutilation, namely lip biting. The key to extinguishing this behaviour was to address the children's psychological needs. Department of Psychology, St George's Hospital Medical School, London, UK. g.colville@sghms.ac.uk
- Dearolf WW, 3rd, Betz RR, Vogel LC, Levin J, Clancy M and Steel HH (1990). Scoliosis in pediatric spinal cord–injured patients. *J Pediatr*

Orthop **10**:214–8. Summary: One hundred thirty children who sustained spinal cord injuries between birth and age 21 years were reviewed to determine the progression rate of paralytic scoliosis and the effects of bracing and surgery. Patients were divided into two groups: those injured before and those injured after the adolescent growth spurt. Scoliosis developed in 97 and 52%, respectively. Bracing was effective in delaying progression in the preadolescent group. The progressive paralytic spinal deformity did not appear to be related to the level of injury. The older patient is at much less risk for paralytic scoliosis, but still requires routine examination. Shriners Hospital for Crippled Children, Philadelphia, Pennsylvania 19152.

- Defresne P, Meyer L, Tardieu M, Scalais E, Nuttin C, De Bont B, Loftus G, Landrieu P, Kadhim H and Sebire G (2001). Efficacy of high dose steroid therapy in children with severe acute transverse myelitis. *J Neurol Neurosurg Psychiatry* **71**:272–4. Summary: No effective treatment has been demonstrated for patients with acute transverse myelopathy. In a multicentre controlled study, 12 children with severe acute transverse myelopathy were treated with intravenous methylprednisolone (IVMP) and compared with a historical group of 17 patients. The treatment had a significant effect on the proportion of patients walking independently at 1 month and on the proportion with full recovery at 1 year, with no differences in the frequency of complications between the two groups. Service de Neurologie, Departement de Pediatrie, Cliniques Universitaires Saint-Luc, Universite Catholique de Louvain, Avenue Hippocrate 10, 1200 Bruxelles, Belgium. pierre.defresne@freebel.net

- Dickman CA, Zabramski JM, Hadley MN, Rekate HL and Sonntag VK (1991). Pediatric spinal cord injury without radiographic abnormalities: report of 26 cases and review of the literature. *J Spinal Disord* **4**:296–305. Summary: Spinal cord injury without radiographic abnormality (SCIWORA) occurs primarily in the pediatric population but is less common than other forms of spinal injury among children. Between 1972 and 1990, 159 pediatric patients were admitted to the Barrow Neurological Institute with acute traumatic spinal cord or vertebral column injuries. Of these, 26 children (16%) sustained SCIWORA. The mechanism of injury, its severity, and the prognosis for recovery were related to the patient's age. In young children, SCIWORA accounted for 32% of all spinal injuries and tended to be severe; 70% were complete injuries. In older children, SCIWORA accounted for only 12% of the spinal injuries, was rarely associated with a complete injury, and had an excellent prognosis for complete recovery of neurologic function. As with other types of spinal cord injuries, the severity of neurological injury was the most important predictor of outcome. Patients with complete neurological deficits from SCIWORA had



a poor prognosis for recovery of neurological function. Division of Neurological Surgery, Barrow Neurological Institute, Phoenix, Arizona.

- Durkin MS, Olsen S, Barlow B, Virella A and Connolly ES, Jr. (1998). The epidemiology of urban pediatric neurological trauma: evaluation of, and implications for, injury prevention programs. *Neurosurgery* 42:300–10. Summary: OBJECTIVE: To describe the incidence and causes of pediatric head, spinal cord, and peripheral nerve injuries in an urban setting and to assess the implications of these data for injury prevention programs. METHODS: Pediatric deaths and hospital admissions secondary to neurological trauma included in the Northern Manhattan Injury Surveillance System from 1983 to 1992 were linked to census counts to compute incidence rates. Rates before the implementation of a nonspecific injury prevention program were compared with rates after the implementation, and rates for the target population were compared to rates for the control population. Rates were analyzed on the basis of the cause of injury as well as the age, gender, and neighborhood income level of the injured. RESULTS: The incidence of neurological injuries resulting in hospitalization or death was 155 incidents per 100,000 population per year; the mortality rate was 6 people per 100,000 population per year. Neurological injuries represented 18% of all pediatric injuries and accounted for 23% of all traumatic deaths. Spinal cord and peripheral nerve injuries were relatively rare (5%) compared to head injuries (95%). Minor head injuries, including isolated cranial fractures, minor concussions (<1 h loss of consciousness), and unspecified minor head injuries, accounted for the majority of neurological injuries (76%), whereas severe head injuries, including severe concussion (>1 h loss of consciousness), cerebral laceration/contusion, intracerebral hemorrhage, and unspecified major injuries, were less common (18% of all neurological injuries). Boys were more often affected than girls at every age, and this preference increased with age. Children younger than 1 year showed the highest incidence of both major and minor injuries. One- to 4-year olds showed the lowest rates, with steady increases thereafter. Traffic accidents and falls were the leading causes (38 and 34%, respectively), and assaults were the next leading causes (12%). Among children admitted to surveillance system hospitals, falls were most common in children younger than 4 years, pedestrian motor vehicle accidents were most common in late childhood, and assaults were most common in early adolescence. Case:fatality rates were 5 to 7% for all age groups except 5- to 12-year-olds, for whom the case:fatality rate was 1.9%. Residence in a low-income neighborhood was associated with an increased risk of injury (rate ratio, 1.71; confidence interval, 95%, 1.54, 1.89). The average hospitalization cost per injury was \$8502. Medicaid (54%) and other government sources (5%) covered the majority of expenses, including indirect reimbursement of usually uncollected self-

pay billing (19%). Although injury incidence rates fell in both the control and intervention cohorts during implementation of a nonspecific injury prevention program, targeted age and population groups demonstrated greater relative reductions in injuries than nontargeted ones, suggesting a positive effect. **CONCLUSIONS:** Deaths and hospital admissions secondary to pediatric neurological trauma represent a significant public health problem, with the majority of the direct cost being born by government agencies. Future efforts to prevent neurological trauma in children who live in inner cities should focus on families with low incomes and provide novel education programs regarding infant abuse, infant neglect, and infant injury avoidance. Age-appropriate school-based programs should also be developed to address traffic safety and conflict resolution. Division of Epidemiology, Gertrude H. Sergievsky Center, Columbia University, New York, New York, USA.

- Eleraky MA, Theodore N, Adams M, Rekate HL and Sonntag VK (2000). Pediatric cervical spine injuries: report of 102 cases and review of the literature. *J Neurosurg* **92**:12–7. **Summary:** **OBJECT:** To evaluate and review their experience with pediatric cervical injuries and factors affecting outcome, the authors conducted a retrospective clinical study of 102 cases (65% boys, 35% girls) of pediatric cervical spine injuries treated in the last decade. This study is an extension of and comparison with their earlier experience. **METHODS:** Patients were divided into two age groups—birth to 9 years (Group 1) and 10 to 16 years of age (Group 2)—and managed according to status at presentation and type of injury. Thirty patients were managed surgically and 72 non-surgically (42 wore a halo brace and 30 wore hard collars or custom-molded braces). Motor vehicle accidents were the most common cause of injury, and 40% were associated with head injury. Patients in the younger-age group (Group 1) sustained more neurological injuries than the older patients in Group 2, and most injuries were in the upper cervical spine. Of the 38 children in Group 1, in 39% a subluxation was present and in 29% a fracture or fracture/subluxation was demonstrated. Of the patients in Group 2, 80% had sustained fractures or fracture/subluxations. Vertebral fractures were the most common radiological findings (32%). At late follow-up review (mean 5 years), solid fusions were demonstrated in all patients. Neurological deterioration did not occur in any patient. The mortality rate was 16%. Compared with the authors' earlier report, the incidence of cases with pediatric cervical injuries increased, as did the number managed surgically. Various fusion techniques were used, and neurological and fusion outcomes improved as compared with the previous report. **CONCLUSIONS:** The prognosis of neurological recovery from pediatric cervical spine injuries is related to the severity of the initial neurological injury. Management must be tailored to the patient's age, neurological status, and type and level of injury. Compared with our

earlier experience, fusion and instrumentation procedures were used more frequently. Different types of fusion and instrumentation procedures can be performed safely in children and produce good outcomes. Division of Neurological Surgery, Barrow Neurological Institute, St. Joseph's Hospital and Medical Center, Phoenix, Arizona, USA.

- Ellsworth PI, Webb HW, Crump JM, Barraza MA, Stevens PS and Mesrobian HG (1996). The Malone antegrade colonic enema enhances the quality of life in children undergoing urological incontinence procedures. *J Urol* **155**:1416–8. Summary: Purpose: Functional alterations of the gastrointestinal and genitourinary tracts, and physical limitations in children with spina bifida, imperforate anus and spinal cord injury challenge the ability to have independent fecal and urinary continence. Urologists have successfully helped these patients achieve urinary continence. We report our experience with the antegrade colonic enema procedure, which allows select individuals to achieve continence of stool, enhancing quality of life. Materials and Methods: Since December 1992, 18 antegrade colonic enema procedures were performed in 12 female and 6 male patients 5 to 31 years old of whom 14 had spina bifida, 2 had imperforate anus and 2 had spinal cord injury. Simultaneous urological continence procedures were performed in 8 patients, including appendicovesicostomy in 4, augmentation cystoplasty in 2 and augmentation cystoplasty plus an ileal Mitrofanoff procedure in 2. Four patients previously underwent urological reconstruction. Results: In 24 months of followup (average 6.6) all patients with a functioning stoma remained continent of stool and 17 were continent of urine. Complications related to the antegrade colonic enema procedure occurred in 4 children (22%) of whom 3 required further surgery. Three patients (17%) had minor stomal stenosis. Conclusions: The antegrade colonic enema procedure is easily performed and it should be considered for any child with significant physical limitations and/or refractory fecal incontinence before urological continence promoting procedures are done. Division of Urology, University of Florida, Jacksonville, Florida, USA.

- Garcia RA, Gaebler-Spira D, Sisung C and Heinemann AW (2002). Functional improvement after pediatric spinal cord injury. *Am J Phys Med Rehabil* **81**:458–63. Summary: OBJECTIVE: To describe the functional gain (FGain) with pediatric spinal cord injury inpatient rehabilitation and to identify the relationship of various factors to FGain in pediatric spinal cord injury inpatient rehabilitation. DESIGN: Retrospective chart review of a series of 91 children with spinal cord injury admitted from 1993 to 1998 in a freestanding rehabilitation hospital. Admission and discharge functional status were assessed with the Pediatric Functional Independence Measure (WeeFIM) instrument for children  $\leq 7$  yr and the Adult Functional Independence Measure (FIM) instrument for children

>7 yr. The outcome measure is the FGain (difference between the discharge and admission functional status). RESULTS: Significant gains in functional status were observed in all patients. FGain was not significantly related to age, sex, length of inpatient rehabilitation, pathogenesis, or completeness or neurologic level of injury. However, there was a trend for higher FGain for patients with incomplete spinal cord injury and traumatic spinal cord injury. CONCLUSIONS: Functional improvement occurs with pediatric spinal cord injury inpatient rehabilitation. There is a trend for higher FGain in patients with less severe injury and traumatic injury. The lack of relationship between FGain and length of inpatient rehabilitation suggests that a variety of other factors influence the relationship between FGain and length of inpatient rehabilitation. Department of Physical Medicine and Rehabilitation, Northwestern University Medical School, and the Rehabilitation Institute of Chicago, Illinois, USA.

- Giglio AM, Rovella C, Botindari E and Alba M (2002). [The phrenic nerve stimulator, a valid ventilatory support in the management of quadriplegic patients receiving home health care services. A case report]. *Minerva Anestesiologica* **68**:567–71. Summary: The authors describe the case of a quadriplegic child with post-traumatic respiratory insufficiency and total dependency on mechanical ventilation. The child was a long-term inpatient at the Pediatric Intensive Care Unit of Palermo. Considering the patient's long life expectancy, psychological distress and determination of the patient and family members to have the patient at home again, the plan for dehospitalization included the use of a phrenic stimulator as a supplement to conventional mechanical ventilation that would simplify home health care and improve the patient's quality of life.

Electromyography, fluoroscopy and gas analysis were conducted to evaluate whether the patient was physically fit to receive a stimulator. The device was then implanted at the Spinal Cord Injury Treatment Unit in Sondalo. The stimulator is compact in design, operates silently, and affords more natural ventilation without interfering with breathing rhythm, and maintains muscle trophism. In combination with mechanical ventilation, the pacing device is an ideal system for home respiratory assistance. Additional benefits include increased patient mobility outside the home and improved quality of life. The system provides good respiration, as shown by EtCO<sub>2</sub> and SpO<sub>2</sub> measurements and long-term monitoring performed at our unit. Servizio di Anestesia e Rianimazione Pediatrica, Ospedale dei Bambini G. Di Cristina, Palermo, Italy.

- Grandas OH, Klar M, Goldman MH and Filston HC (2000). Deep venous thrombosis in the pediatric trauma population: an unusual event: report of three cases. *Am Surg* **66**:273–6. Summary: The incidence of deep venous thrombosis (DVT) in the pediatric population has been reported to be lower than in adults. Pediatric trauma patients have predisposing risk

factors for DVT similar to those in the general trauma population. We reviewed the records of 2746 children under 16 years of age admitted to our Level I pediatric trauma service from 1989 to 1997. Only three cases of DVT were documented, all adolescents. DVT was located in the upper (n = 1) and lower (n = 1) extremity venous system. One patient presented with pulmonary embolism alone without identifiable DVT. Risk factors found were venous system manipulations, including atriocaval shunt, subclavian central line, and hyperinflated medical antishock trousers garment. Therapy consisted of heparin followed by warfarin anticoagulation. A vena cava filter was inserted in one patient for whom systemic anticoagulation was contraindicated. No DVT was seen in 1123 closed head injury patients or 29 spinal cord injury patients without associated risk factors. The thrombotic risk in pediatric trauma patients is low. Routine screening or prophylaxis is not indicated except for patients who are likely to remain immobile for an extended period of time and require prolonged rehabilitation, have venous manipulations, or present with clinical symptoms. Hematologic evaluation in patients with diagnosed DVT is necessary to identify individual risk factors. Department of Surgery, University of Tennessee Graduate School of Medicine, Knoxville, USA.

- Hadley MN, Zabramski JM, Browner CM, Rekate H and Sonntag VK (1988). Pediatric spinal trauma. Review of 122 cases of spinal cord and vertebral column injuries. *J Neurosurg* **68**:18–24. Summary: A review of 122 pediatric cases of vertebral column and spinal cord injuries is presented. These relatively uncommon injuries can be characterized by four distinct injury patterns: fracture only, fracture with sublaxation, sublaxation only, and spinal cord injury without radiographic abnormality. The immature pediatric spine has several anatomical and biomechanical features that distinguish it from the mature adolescent spine and, accordingly, the frequency of the injury type, the level of spine injury, and the incidence of neurological compromise were found to vary with the age of the patient. Follow-up data were obtained in 93% of the cases (median duration 44 months). No patient was made worse by treatment, 89% of the patients with incomplete myelopathy on admission were improved on their last examination, and 20% of the patients with a complete myelopathy had evidence of significant recovery of function. The authors conclude that the outcome after pediatric spinal trauma is good. Division of Neurological Surgery, Barrow Neurological Institute, Phoenix, Arizona.
- Hakenberg OW, Ebermayer J, Manseck A and Wirth MP (2001). Application of the Mitrofanoff principle for intermittent self-catheterization in quadriplegic patients. *Urology* **58**:38–42. Summary: OBJECTIVES: Patients with cervical spinal cord lesions have impaired hand

function, which often prohibits clean intermittent self-catheterization (CIC), especially in female patients. Enabling these patients to perform CIC gives them control of their bladder management and can improve their quality of life considerably. We have used an appendicovesicostomy to provide easy access for CIC in such patients. METHODS: Five patients (4 women, 1 man) with a mean age of 31 years (range 20 to 52) and a mean duration of the cervical cord lesion of 22 months (range 7 to 37) underwent appendicovesicostomy. Three patients were young victims of motor vehicle accidents, 1 patient had a progressive rheumatoid arthritic disorder, and 1 patient had a complex functional paraplegia syndrome and underwent bladder augmentation at the same time. RESULTS: The surgical procedure with the creation of a catheterizable stoma in the right lower abdominal quadrant was successful in all cases but was complicated by mechanical ileus in the patient with simultaneous bladder augmentation. All patients learned to perform independent CIC with continuing anticholinergic medication. Stomal stenosis did not occur in any of the 5 patients, and urinary tract infections occurred once in 2 patients and repeatedly in 1 patient. Three of 5 patients have been enabled by independent bladder management to achieve occupational rehabilitation. CONCLUSIONS: Appendicovesicostomy is a suitable procedure in patients with cervical spinal cord lesions who are otherwise unable to perform independent CIC. The creation of a catheterizable abdominal stoma enables these patients to gain independent control of their bladder management. However, caution in patient selection is advisable as probably the best results are achieved in highly motivated, younger patients with traumatic cervical cord lesions. Department of Urology, University Hospital Carl-Gustav Carus, Dresden, Germany.

- Hamilton MG and Myles ST (1992). Pediatric spinal injury: review of 174 hospital admissions. *J Neurosurg* 77:700–4. Summary: Injury to the spinal column and spinal cord occurs relatively infrequently in the pediatric population. A review of 174 pediatric patients is presented, representing 5.4% of all patients admitted with spinal injury. Spinal cord injury was present in 45% of patients. A distinct injury profile, explained by anatomical and biomechanical features, distinguishes the young patient with an immature spine from older adolescents with a more mature, adult-like spine. The younger patients, while less likely to have spinal injury, had a higher incidence of neurological injury, in addition to a higher frequency of both spinal cord injury without radiological abnormality and upper cervical cord injury. In addition, younger patients with spinal cord injury and no radiological abnormality were more likely to have complete or severe cord injury. Prognosis was determined by the severity of spinal cord injury. Patients with complete cord injuries showed little improvement, while patients with incomplete injuries generally fared much better, with 74% showing significant improvement and 59%

experiencing a complete recovery of neurological functions. There were six deaths, but none was attributed solely to spinal injury. The authors conclude that outcome is quite good after pediatric spinal cord injury that does not produce a physiologically complete cord deficit. Department of Clinical Neurosciences, University of Calgary, Alberta, Canada.

- Hickey KJ and Vogel LC (2002). Autonomic dysreflexia in pediatric spinal cord injury. *SCI Nurs* **19**:82–4. Summary: Shriners Hospitals for Children, Chicago, Illinois, USA.
- Hicsonmez G, Tunc B, Olcay L and Tuncer MA (2001). Effect of short-course, high-dose steroid therapy in a child with myelodysplastic syndrome. *Pediatr Hematol Oncol* **18**:525–9. Summary: High-dose methylprednisolone (HDMP) has been shown to induce differentiation of myeloid leukemic cells with a remarkable antileukemic effect in children with various subtypes of acute myeloblastic leukemia (AML). Here the beneficial effect of short-course HDMP therapy in a child with myelodysplastic syndrome (MDS) is reported. Oral methylprednisolone sodium succinate (Prednol-L) was administered at a single daily dose of 30 mg/kg for 5 days to a 4-year-old girl with refractory anemia with excess of blasts and hypocellular bone marrow before the initiation of chemotherapy. In addition to dramatic clinical improvement, the patient's white blood cell count increased from  $2.3 \times 10^9/L$  to  $5.0 \times 10^9/L$ , and peripheral blood blast cells disappeared 4 days after HDMP treatment. Repeated bone marrow aspirate 1 week after the initiation of HDMP disclosed increased cellularity with no blasts. Furthermore, short-course HDMP treatment stimulated the increase in the number of peripheral blood lymphocytes and CD3+, CD4+, CD8+, CD19+, CD34+, and NK cells. Results obtained with HDMP from the previous studies and the present case suggest that high-dose methylprednisolone is a promising agent in the treatment of AIDS and it is recommended as an initial treatment especially for MDS children with hypocellular bone marrow at presentation. Department of Hematology, Ihsan Dogramaci Children's Hospital, Hacettepe University, Ankara, Turkey.
- Holmes NM, Kogan BA and Baskin LS (2001). Placement of artificial urinary sphincter in children and simultaneous gastrocystoplasty. *J Urol* **165**:2366–8. Summary: PURPOSE: Previous studies have described placement of an artificial urinary sphincter and simultaneous augmentation cystoplasty with a segment of bowel. Conclusions from these studies indicated that infection rates were higher and a staged approach should be undertaken. Others have suggested that concurrent urinary reconstruction with stomach and sphincter placement can be performed safely. Results comparing infection rates of simultaneous sphincter placement and gastrocystoplasty versus staged sphincter

placement and augmentation cystoplasty using a segment of ileum or stomach versus sphincter placement alone in a pediatric population have not been previously described to our knowledge. We reviewed these various groups of patients to determine if the difference in infectious complications were clinically and statistically significant. **MATERIALS AND METHODS:** A retrospective review of medical records from 1986 to 1999 identified 28 pediatric patients (age 18 years or less) who had undergone placement of an AS800dagger artificial urinary sphincter. Data points were collected focusing on etiology of the neurogenic bladder, age at time of surgery, types of surgery performed, length of followup and complication rates. **RESULTS:** Complete data were available for 27 of the 28 patients. Neurogenic bladder was secondary to myelomeningocele in 25 cases, transverse myelitis in 1 and spinal cord injury in 2. Mean patient age at surgery was 12.7 years (range 6.1 to 18.2) and mean followup was 4.3 years (range 1 month to 13 years). Simultaneous gastrocystoplasty was performed in 7 cases (group 1), staged sphincter placement followed by augmentation cystoplasty with a segment of ileum or stomach was done in 8 (group 2) and 12 did not require bladder augmentation (group 3). Urethral device erosion requiring explantation was the most common complication, occurring in 3 patients in group 1 and 2 in group 3 ( $p = 0.101$ ). Mean time to erosion was 22.1 months (range 2 to 46.4). Previous surgery (bladder neck or hernia repair) was a common factor in each group with complications. Urine cultures and culture of the explanted device were positive in 2 patients in group 1. **CONCLUSIONS:** Simultaneous placement of artificial urinary sphincter at the time of gastrocystoplasty can be performed in carefully selected patients, although those undergoing staged procedures did well without complications. Prior bladder neck surgery seems to be a significant risk for infection. A staged approach to lower urinary tract reconstruction would be more advantageous due to the absence of infection and erosion in those undergoing staged sphincter placement and augmentation cystoplasty. Division of Urology, Albany Medical College, Albany, New York, USA.

- Johnston TE, Betz RR, Smith BT and Mulcahey MJ (2003). Implanted functional electrical stimulation: an alternative for standing and walking in pediatric spinal cord injury. *Spinal Cord* **41**:144–52. Summary: **STUDY DESIGN:** Post intervention, repeated measures design, comparing two interventions. **SETTING:** Orthopedic pediatric hospital specializing in spinal cord injury. **METHODS:** Nine subjects, ages 7–20 years, received an eight-channel implanted lower extremity functional electrical stimulation (FES) system for standing and walking. Electrodes were placed to stimulate hip and knee extension, and hip abduction and adduction. Standing and walking were achieved through constant stimulation to the implanted muscles, allowing a swing through gait pattern with an



assistive device. After training with FES and long leg braces (LLB), subjects were tested in eight upright mobility activities, which were scored based upon completion time and level of independence. RESULTS: Seven subjects completed data collection. These subjects completed four activities faster ( $P < 0.02$ ) and five activities more independently ( $P < 0.025$ ) with FES as compared to LLB. Transitions between sitting and standing, which were scored in isolation for two mobility activities, were achieved faster and with more independence with FES. In addition, subjects reported preferring FES for the majority of activities. No activity required more time or more assistance to complete with FES as compared to LLB. CONCLUSION: The implanted FES system provided these subjects with enhanced functional abilities over traditional LLB and decreased the need for physical assistance by a caregiver, suggesting that it is a realistic alternative for upright mobility in a pediatric population with spinal cord injury. Shriners Hospitals for Children, Philadelphia, Pennsylvania, USA.

- Kannisto M, Alaranta H, Merikanto J, Kroger H and Karkkainen J (1998a). Bone mineral status after pediatric spinal cord injury. *Spinal Cord* 36:641–6. Summary: The impact of spinal cord injury (SCI) on later bone mineral status was studied in 35 adults who had sustained their injury in childhood. The median age of the patients was 31 years, the median age at injury 12.9 years and the median time period from injury was 19 years. The methods used in the study were clinical interview and examination, measurement of bone mineral density (BMD) of the lumbar spine and the proximal femur with dual energy X-ray absorptiometry (DEXA) and estimation of bone turnover with biochemical markers. The densitometric examination revealed that the BMD at the lumbar spine was within the normal range but grossly decreased in the femoral region. Moreover, there was a significant difference in BMD between patients with high (C2–T6) and low (below T6) lesions in the lumbar spine as well as in the femoral region. Patients with lower lesions had higher BMD values. The markers of bone turnover which were studied were serum and urinary calcium and phosphate serum alkaline phosphatase and its isoenzymes, osteocalcin, carboxyterminal propeptide of human type I procollagen (PICP), carboxyterminal telopeptide of type I collagen (ICTP) and urinary deoxypyridinoline. These markers of bone metabolism showed no signs of ongoing accelerated bone formation or resorption. The present study suggests that caution should be observed in weight bearing training or mobilisation of patients with pediatric SCI or perhaps with long standing SCI because of increased fracture risk. The prevention of dissociated osteoporosis should be investigated further in order to avoid fractures of weakened bones. The modes of prevention might be found in the use of modern pharmacotherapy of osteoporosis and from correctly dosage physical training. Children's Hospital, University of Helsinki, Finland.

- Kannisto M, Merikanto J, Alaranta H, Hokkanen H and Sintonen H (1998b). Comparison of health-related quality of life in three subgroups of spinal cord injury patients. *Spinal Cord* 36:193–9. Summary: Health-related quality of life (HRQL) was evaluated in three subgroups of spinal cord injury (SCI) patients: (1) persons who had sustained a pediatric SCI (mean time from injury 20 years, age at injury 11.3 years, n = 36), (2) newly injured patients at the beginning of acute rehabilitation (mean age 35.3 years, n = 31), and (3) patients with a chronic SCI (mean time from injury 4.8 years, mean age at injury 35.2 years, n = 34). All the patients were clinically examined and structurally interviewed with a list of questions dealing with details of anamnestic information about injury, its treatment, possible complications and persons past and present psychosocial condition. HRQL was assessed by a generic fifteen-dimensional self-administered instrument (15D). The relative importance of the 15D dimensions and an overall judgement of health status were measured by a 0–100 visual analogue scale. Average importance weights of the dimensions of moving and working differed significantly in the three subgroups. Patients with pediatric SCI assigned the lowest importance for moving. The newly injured patients highly valued working capability. The HRQL scores of the patients who had sustained their injury in childhood were significantly higher than those of the newly injured patients or chronic patients. The tetraplegic patients estimated their HRQL significantly lower than patients with incomplete paraplegia. Of the three subgroups studied, those with pediatric SCI were well adjusted on the basis of anamnestic information and scored high on HRQL when compared with the other two subgroups. Patients injured in adulthood rated their overall HRQL lower and were often unable to return to work. Patients injured in childhood expressed better performance in physical functions than patients who had sustained their injury in adulthood. The subgroups did not differ in psychological functions. Children's Hospital, University of Helsinki, Finland.
- Kannisto M and Sintonen H (1997). Later health-related quality of life in adults who have sustained spinal cord injury in childhood. *Spinal Cord* 35:747–51. Summary: The outcome in terms of health-related quality of life (HRQL) in pediatric spinal cord injury (SCI) was studied in 36 adults who had sustained an SCI in childhood. The patients were interviewed and clinically examined. HRQL was assessed with the 15D, a generic fifteen-dimensional self-administered HRQL instrument. The 15 multiple-level dimensions are moving, seeing, hearing, breathing, sleeping, eating, communicating, urinary continence, working, social participation, mental functioning, pain, depression, distress and perceived health. The respondents choose, for each dimension, the level that best describe their health status. In the 15D valuation system the

respondents first assign a relative importance weight to each dimension and then a relative value to the levels on each dimension. To derive the 15D HRQL score on a 0–1 scale the level values and importance weights are multiplied and combined with the levels chosen. The average HRQL score of this SCI group was significantly lower than that measured in the population sample. The average importance weights assigned by the SCI group differed significantly ( $P < 0.05$ ) from those assigned by the general population on several dimensions. The weights assigned by the SCI group were higher for the dimensions of mental functioning, communicating, social participation and seeing and lower for moving, working, sleeping and eating. These differences in valuing the dimensions of HRQL can influence behaviour and should therefore be taken into consideration in rehabilitation. Children's Hospital, University of Helsinki, Finland.

- Keen TP (1990). Nursing care of the pediatric multitrauma patient. *Nurs Clin North Am* 25:131–41. Summary: Pediatric multitrauma causes more deaths and injuries each year in children than any other cause of death. Most of the multitrauma cases involve a motor vehicle accident. Blunt trauma and head injuries constitute the majority of injuries in pediatric multitrauma. Blunt trauma leaves minimal evidence of the underlying injury and is difficult to assess in the unconscious child. The initial assessment in children is in some ways more complex than in an adult. The airway is a more critical concern in the child. Airway obstruction is a more frequent cause of ventilatory insufficiency in pediatric trauma. Hypothermia is a vital concern because children lack the ability to maintain their temperature when they are compromised. Assessment of circulation and shock in children is complicated because the signs of shock are subtle in the child. The plan of care and the approach to the child must incorporate the child's fears and coping mechanisms based on the child's age and developmental level. Nursing diagnoses should reflect the plan of care not only for the child, but for his or her family. The proper approach to the child can positively influence the quality of the assessment, the level of cooperation, and the long-term outcome of care. Richland Memorial Hospital, Columbia, South Carolina.
- Kenter K, Worley G, Griffin T and Fitch RD (2001). Pediatric traumatic atlanto–occipital dislocation: five cases and a review. *J Pediatr Orthop* 21:585–9. Summary: Traumatic atlanto–occipital dislocation (AOD) has been thought to be a rare and fatal injury. Recently, more survivors, especially children, have been reported. During a 10–year period, the authors have encountered five children with traumatic AOD. A retrospective review of traumatic AOD in children from 1985 to 1995 was performed. Clinical presentation, initial radiologic findings, and final outcome were emphasized. Distance from the dens to the basion and the ratio of Powers were measured from initial lateral cervical spine

radiographs. The average distance from the dens to the basion was 9.8 mm. The average ratio of Powers was 1.38. There were three survivors, two having a concomitant spinal cord injury. All survivors underwent a posterior occipitovertebral fusion. Three cases initially went undiagnosed. The diagnosis of AOD by lateral cervical spine radiographs can be difficult. The authors recommend detailed measurements of the initial cervical spine radiographs in pediatric patients at risk for traumatic AOD. Division of Orthopaedic Surgery, Duke University Medical Center, Durham, North Carolina, USA. kenterk@health.missouri.edu

- Kokoska ER, Keller MS, Rallo MC and Weber TR (2001). Characteristics of pediatric cervical spine injuries. *J Pediatr Surg* **36**:100–5. Summary: PURPOSE: The objective of this study was to assess the mechanisms and patterns of injury and outcome in children with cervical (C) spine trauma. METHODS: We reviewed the National Pediatric Trauma Registry between April 1994 and March 1999 and identified (by ICD–9 criteria) all cases of blunt trauma victims with cervical fractures, dislocations, and spinal cord injuries without radiographic abnormality (SCIWORA). Data are shown as mean +/- SEM. RESULTS: During the 5-year period, the incidence of blunt C–spine injury was 1.6% (n = 408 of 24,740 total entries). Mean age was 10.5 +/- 0.3 (1 to 20) years, and 59% were boys. Leading mechanisms were motor vehicle accidents (n = 179; 44%), sports (n = 66; 16%), and pedestrian injuries (n = 57, 14%). Younger (< or =10 years) children more often sustained high (C1 to C4) vs low (C5 to C7) injuries (85% v 57%; P<.01) and also had a higher incidence of dislocations (31% v 20%; P<.01) and cord injuries (26% v 14%; P<.01), whereas older children had more C–spine fractures (66% v 43%; P<0.01). Mortality rates (overall, 17%) were higher in younger children (n = 180) when compared with older children (n = 228; 30% v 7%; P<.01). Overall, the majority of deaths (93%) were associated with brain injuries. No children with cervical dislocations had neurologic sequelae. The preponderance of children with fractures (83%) also were without neurologic injury, whereas those associated with SCIWORA usually were (80%) partial. Overall, complete cord lesions were infrequent (4%). CONCLUSIONS: These data, representing the largest series to date, confirm that blunt C–spine injuries in children are rare. Patterns of injury vary significantly according to child age. Major neurologic sequelae in survivors is uncommon, does not correlate well with cord level, and rarely is complete. Division of Pediatric Surgery, Department of Surgery, Saint Louis University Health Sciences Center and Cardinal Glennon Children's Hospital, St Louis, MO 63104, USA.
- Lalonde F, Letts M, Yang JP and Thomas K (2001). An analysis of burst fractures of the spine in adolescents. *Am J Orthop* **30**:115–20. Summary: Burst fractures are less common in children than in adults because of the greater mobility and elasticity of the pediatric spine. Because of these

spine characteristics, these fractures may behave differently in childhood than in adulthood. To try to address these differences, we reviewed our experience with 11 children (5 boys, 6 girls) treated for burst fractures. Average age at time of injury was 14.4 years. Follow-up averaged 9 years. All fractures were categorized using the Denis classification system for burst fractures. Three children had associated spinal cord injury. Five children were treated with nonoperative bedrest and casting; the other 6 children, who had the most severe burst fractures, were treated with posterior spinal fusion and instrumentation. Satisfactory functional results were found in 90% of the children at follow-up. Radiological evaluation at initial and follow-up examination showed that children treated operatively improved or maintained their fracture kyphosis (range, 12 degrees – 19 degrees). Anterior vertebral compression improved an average of 15% (range, 24%–39%). In the children treated nonoperatively, kyphosis progressed an average of 9 degrees (range, 15 degrees – 24 degrees), and anterior vertebral compression increased a further 8% (range, 36%–44%). Our results showed that (a) the children who sustained burst fractures tended to develop mild progressive angular deformity at the site of the fracture, (b) operative stabilization prevented further kyphotic deformity as well as decreased the length of hospitalization without contributing to further cord compromise, and (c) nonoperative treatment of burst fracture was a viable option in neurologically intact children, but progressive angular deformity occurred during the first year after the fracture. Division of Pediatric Orthopaedics, Children's Hospital of Eastern Ontario, University of Ottawa, Canada.

- Massagli TL, Dudgeon BJ and Ross BW (1996). Educational performance and vocational participation after spinal cord injury in childhood. *Arch Phys Med Rehabil* 77:995–9. Summary: OBJECTIVE: To examine educational achievement and vocational success of children with SCI. DESIGN: Surveys administered to students and teachers, and content analysis of school records. SETTING: Regional pediatric rehabilitation program. PARTICIPANTS: Participants were selected from 144 children with SCI treated from 1979 through 1992; 98 met inclusion criteria of onset of SCI before the age of 18 years, older than 3 years, residual paresis, and no cognitive impairment; 29% were lost to follow-up, and 53 of the 70 contacted were enrolled. MAIN OUTCOME MEASURES: School completion rates, absenteeism, grades, ratings of participation; education and living situations after high school; history of paid employment. RESULTS: The 53 responders were: 33 boys, 20 girls; 25 with paraplegia (47%), 28 with tetraplegia (53%); mean length of disability = 9.4 years; 12 primary students (23%), 19 secondary students (36%), and 22 postsecondary participants (41%). Students and teachers rated student participation and performance as average or above compared to peers; 84% of secondary students planned to attend college after graduation.

Only 33% of high school students over age 15 had been employed. Ninety-one percent of postsecondary subjects had graduated from high school. Seven (32%) had graduated from college or a vocational program, 11 (50%) were enrolled in college full- or part-time, and 4 others (18%) were neither in school nor employed. Current employment rates were 71% of college graduates, 36% of those in college, and 0% of those who had never enrolled. Level of SCI was not related to employment.

CONCLUSIONS: Students with SCI demonstrate adequate participation and performance in educational settings, but may benefit from more vocational counseling and opportunities for paid employment.

Department of Rehabilitation Medicine, University of Washington, Seattle, USA.

- Matsui M, Kawano H, Matsukura M, Otani Y and Miike T (2002). Acute transverse myelitis after Japanese B encephalitis vaccination in a 4-year-old girl. *Brain Dev* 24:187–9. Summary: Fourteen days after Japanese B encephalitis (JBE) vaccination, a 4-year-old girl developed the full clinical manifestation of ATM within 24h. She showed acute ascending flaccid paraplegia with sensory disturbance, bladder dysfunction and meningeal sign. Cerebrospinal fluid examination revealed neutrophil pleocytosis and elevated protein level. Magnetic resonance imaging (MRI) showed diffuse swelling of the cervical and lumbar cord with low signal intensity on T1 and high signal intensity on T2-weighted imaging. These findings suggested that she had developed meningo-radiculomyelopathy. Since sequential MRI studies showed prompt reduction of the cord swelling, the high-dose methylprednisolone therapy employed seemed to have been effective for improvement of inflammation. Even with such potent drug treatment, she still has substantial flaccid diplegia and sphincter disorder 1 year later, and so we are convinced that the pathological change of the cord was as severe as in necrotizing myelopathy. Although the pathological process remains unknown, cellular autoimmune mechanism against the JBE vaccination is suspected. Department of Child Development, Kumamoto University School of Medicine, 1-1-1 Honjo, Kumamoto 860-0811, Japan.

- McCollough NC, 3rd (2000). The evolution of Shriners Hospitals for Children in North America. *Clin Orthop* 187–94. Summary: Shriners Hospitals for Children have been providing totally free care to children with neuromusculoskeletal disabilities since 1922. This mission expanded in 1962 to include the care of children with burn injuries and expanded in 1978 to include children with spinal cord injuries. Today, Shriners Hospitals for Children include 19 hospitals that provide pediatric orthopaedic care, four hospitals that provide acute and reconstructive burn care, and three hospitals in which spinal cord injury rehabilitation centers are located. During the past 20 years, case acuity and complexity

have increased, comprehensiveness of care has been emphasized, members of the medical staff have increasingly become full-time, and sponsored intramural research has increased to a budget of \$22 million annually. Annually, more than 250 orthopaedic residents receive pediatric orthopaedic training and more than 150 surgical residents are trained in pediatric burn care in Shriners Hospitals. In 1998, approximately 25,000 children were admitted for care, more than 22,000 operations were performed, and 236,000 children were treated as outpatients. In 1999, the annual operating budget for Shriners Hospitals for Children was \$397 million.

- Merenda LA (2001). The pediatric patient with SCI--not a small adult! *SCI Nurs* **18**:43-4. Summary: Shriners Hospitals for Children, Philadelphia, Pennsylvania, USA. Imerenda@shrinenet.com
- Moynahan M, Betz RR, Triolo RJ and Maurer AH (1996a). Characterization of the bone mineral density of children with spinal cord injury. *J Spinal Cord Med* **19**:249-54. Summary: The purpose of this study was to compare the bone mineral density in children with spinal cord injury (SCI) with age- and sex-matched controls in three anatomic areas of the proximal hip. In addition, post hoc analysis looked for differences in bone density between sub-groups considering several factors associated with spinal cord injury: the presence or absence of spasticity, the level of injury and the presence or absence of pathologic fractures. Fifty-one pediatric patients with spinal cord injury between the ages of 3 and 20 underwent bone density measurements using dual photon absorptiometry. Before pooling the data across age groups, all measurements were normalized to age- and sex-matched controls because of increasing bone density with growth and higher bone density in males. The results revealed lower bone densities in subjects with SCI as compared with their non-disabled peers, ranging from 56 percent to 65 percent of normal across the three anatomic regions. On the average, subjects who had a previous history of fractures had significantly lower bone density measurements than those without fractures. At the intertrochanteric region, a 10.6 percent difference was noted between subjects with tetraplegia versus those with paraplegia. At the femoral neck and Ward's Triangle, an 8.5 percent difference was noted between subjects with and without spasticity. No conclusions could be drawn from the analyses at the other sites. Together these results begin to characterize bone density levels of the pediatric SCI population. Research Department, Shriners Hospital for Crippled Children, Philadelphia, PA 19152, USA.
- Moynahan M, Mullin C, Cohn J, Burns CA, Halden EE, Triolo RJ and Betz RR (1996b). Home use of a functional electrical stimulation system for

standing and mobility in adolescents with spinal cord injury. Arch Phys Med Rehabil 77:1005–13. Summary: OBJECTIVE: Functional electrical stimulation (FES) is a technology that may allow some patients with spinal cord injury (SCI) to integrate standing and upright mobility with wheelchair mobility. The purpose of this study was to document the patterns of home and community use of a FES system for standing and mobility. DESIGN: A telephone questionnaire was administered every 1 to 4 weeks for a minimum of 1 year. An interview was given at the end of the study to probe the motivators and barriers to home use. SETTING: Training for use of the FES system was performed in an inpatient pediatric rehabilitation setting. Data collection began after the subjects were discharged to home. PARTICIPANTS: Five adolescents with complete, thoracic-level SCI. INTERVENTION: Subjects participated in a program of FES exercise followed by training in basic mobility skills such as standing transfers, maneuvering, level ambulation, one-handed and reaching activities, and stair ascent/descent. MAIN OUTCOME MEASURE: The frequency with which the FES system was used at home and the activities for which it was utilized were documented. Motivators and barriers to FES home use were examined. RESULTS: Subjects donned the FES system on the average once every 3 to 4 days. Between 51% and 84% of the times donned, the system was used for exercise. The remaining times it was used for standing activities, most commonly reaching, one-handed tasks, and standing for exercise. "Motivators" included being able to do things that would otherwise be difficult, perceiving a healthful benefit or a sense of well-being from standing and exercise, and feeling an obligation to stand as a participant in a research study. "Barriers" to FES use included not finding time to use the system, having difficulty seeing opportunities to stand, and being reluctant to wear the FES system all day. Research Department, Shriners Hospitals, Philadelphia, PA 19152, USA.

- Mulcahey MJ (1997). Unique management needs of pediatric spinal cord injury patients: rehabilitation. J Spinal Cord Med 20:25–30. Summary:
- Mulcahey MJ, Betz RR, Smith BT, Weiss AA and Davis SE (1997). Implanted functional electrical stimulation hand system in adolescents with spinal injuries: an evaluation. Arch Phys Med Rehabil 78:597–607. Summary: OBJECTIVE: To study the utility and functional benefits of an implanted functional electrical stimulation (FES) system for hand grasp and release in adolescents with tetraplegia secondary to spinal cord injuries. DESIGN: Intervention study with before–after trial measurement with each subject as his or her own control. SETTING: Nonprofit pediatric orthopedic rehabilitation facility specializing in spinal cord injury. PARTICIPANTS: A convenience sample of five adolescents between 16 and 18 years of age with C5 or C6 level tetraplegia at least 1 year after



traumatic spinal cord injury. Key muscles for palmar and lateral grasp and release were excitable by electrical stimulation. INTERVENTIONS: A multichannel stimulator/receiver and eight electrodes were surgically implanted to provide stimulated palmar and lateral grasp and release. In conjunction with implantation of the FES hand system, surgical reconstruction in the form of tendon transfers, tendon lengthenings and releases, and joint arthrodeses was performed to augment stimulated hand function. Rehabilitation of the tendon transfers and training in the use of the FES hand system were provided. MAIN OUTCOME MEASURES: Measurements of pinch and grasp force, the Grasp and Release Test (GRT), and an assessment of six activities of daily living (ADL) were administered before implantation of the FES hand system and at regular follow-up intervals. Results of the stimulated response of individual muscles and surgical reconstruction were evaluated using standard and stimulated muscle testing techniques and standard assessment of joint range of motion. All subjects completed followup testing. RESULTS: Lateral and palmar forces were significantly greater than baseline forces ( $p = .043$ ). Heavy objects on the GRT could only be manipulated with FES, and FES increased the level of independence in 25 of 30 ADL comparisons (5 subjects, 6 activities) as compared to baseline. After training, FES was preferred in 21 of 30 comparisons over the typical means of task completion. Of the 40 electrodes implanted, 37 continue to provide excellent stimulated responses and all of the implanted stimulators have functioned without problems. The surgical reconstruction procedures greatly enhanced FES hand function by either expanding the workspace in which to utilize FES (deltoid to triceps transfer), stabilizing the wrist (brachioradialis to wrist extensor transfer), or stabilizing joints (intrinsic tenodesis transfer, FPL split transfer). CONCLUSION: For five adolescents with tetraplegia, the combination of FES and surgical reconstruction provided active palmar and lateral grasp and release. Laboratory-based assessments demonstrated that the FES system increased pinch force, improved the manipulation of objects, and typically increased independence in six standard ADL as compared to pre-FES hand function. The study also showed that the five adolescents generally preferred FES for most of the ADL tested. Data on the benefits of the implanted FES hand system outside of the laboratory are needed to understand the full potential of FES. Research Department, Shriners Hospital for Children, Philadelphia, PA 19152, USA.

- Padman R, Alexander M, Thorogood C and Porth S (2003). Respiratory management of pediatric patients with spinal cord injuries: retrospective review of the duPont experience. *Neurorehabil Neural Repair* **17**:32–6. Summary: Pulmonary complications contribute to morbidity and mortality in spinal cord injuries (SCIs). A retrospective review of 20 years of experience with tracheostomy- and ventilator-dependent SCI children is

presented. The authors developed and analyzed a database of 47 children (average age = 11.4 years). Of the patients, 27% had concomitant brain injuries, 6% had prior histories of reactive airway disease, and 2% had thoracic fractures. Injuries were caused by motor vehicle accidents (53%); gunshot wounds (19%); sports-related accidents (19%); and vascular injuries, transverse myelitis, or spinal tumors (8%). Of the injuries, 52% were high level (C1 to C2) and 48% were mid- or low level (C3 to C5). Two groups were analyzed for demographic information. Complications included tracheitis, atelectasis, and pneumonia. Mean tidal volume was 14 cm<sup>2</sup>/kg (maximum = 22 cm<sup>2</sup>/kg). Bedside lung function parameters were attempted to assess readiness and the rapidity of weans. T-piece sprints were used to successfully wean 63% of patients. Successfully weaned patients were compared with those not weaned. No deaths or readmissions for late-onset respiratory failure postwean occurred. The authors' clinical impression favors higher tidal volumes and aggressive bronchial hygiene to minimize pulmonary complications and enhance weaning. Successfully weaned patients had fewer complications. A critical pathway for respiratory management of SCI children is presented. Division of Pulmonology Medicine, Nemours Children's Clinic–Wilmington, Alfred I. duPont Hospital for Children, Wilmington, Delaware, USA. rpadman@nemours.org

- Pang D and Wilberger JE, Jr. (1982). Spinal cord injury without radiographic abnormalities in children. *J Neurosurg* 57:114–29. Summary: Spinal cord injury in children often occurs without evidence of fracture or dislocation. The mechanisms of neural damage in this syndrome of spinal cord injury without radiographic abnormality (SCIWORA) include flexion, hyperextension, longitudinal distraction, and ischemia. Inherent elasticity of the vertebral column in infants and young children, among other age-related anatomical peculiarities, render the pediatric spine exceedingly vulnerable to deforming forces. The neurological lesions encountered in this syndrome include a high incidence of complete and severe partial cord lesions. Children younger than 8 years old sustain more serious neurological damage and suffer a larger number of upper cervical cord lesions than children aged over 8 years. Of the children with SCIWORA, 52% have delayed onset of paralysis up to 4 days after injury, and most of these children recall transient paresthesia, numbness, or subjective paralysis. Management includes tomography and flexion–extension films to rule out incipient instability, and immobilization with a cervical collar. Delayed dynamic films are essential to exclude late instability, which, if present, should be managed with Halo fixation or surgical fusion. The long-term prognosis in cases of SCIWORA is grim. Most children with complete and severe lesions do not recover; only those with initially mild neural injuries make satisfactory neurological recovery.

- Partrick DA, Bensard DD, Moore EE, Calkins CM and Karrer FM (2000). Cervical spine trauma in the injured child: a tragic injury with potential for salvageable functional outcome. *J Pediatr Surg* **35**:1571–5. Summary: BACKGROUND/PURPOSE: Cervical spine injuries are uncommon in children, and, therefore, presumptive immobilization and diagnosis remain controversial. The purpose of this study was to review the author's experience with cervical spine injuries in children to determine the incidence, injury mechanism, pattern of injury, and subsequent functional outcome. METHODS: Fifty-two children over a 6-year period (1994 to 1999) with a cervical spine injury secondary to blunt trauma were identified (1.3% incidence). The functional independent measure (FIM) was assessed at the time of discharge in each of 3 categories: communication, feeding, and locomotion. RESULTS: Mean age of the study children was 10.7 +/- 0.7 years. Eight children (15%) were less than 5 years old, and 4 (8%) were less than 2 years old. The mechanism of injury included motor vehicle crash (52%), falls (15%), bicycle accidents (11%), sports-related injuries (10%), pedestrian accidents (8%), and motorcycle crashes (4%). Seven patients died yielding an overall mortality rate of 13%. Injuries were distributed along the cervical spinal cord as follows: 5 atlanto-occipital dislocations, 28 C1 to C3 injuries, 17 C4 to C7 injuries, and 2 ligamentous injuries. FIM scores were recorded for 18 patients. Seventeen communicated independently, 14 fed themselves independently, and 12 had independent locomotive function. CONCLUSIONS: Cervical spine injuries occur in children across a spectrum of ages. Although atlanto-occipital dislocation is a highly lethal event, children with C1 to C7 injuries have a high likelihood of reasonable independent functioning. Division of Pediatric Surgery, The Children's Hospital, 80218, USA.
- Proctor MR (2002). Spinal cord injury. *Crit Care Med* **30**:S489–99. Summary: Pediatric spinal cord injury is a relatively uncommon problem, responsible for approximately 5% of all spinal cord injuries. Anatomic and behavioral differences between adults and children lead to variation in injury type and severity. Young children are more prone to high cervical injuries, with nearly 80% of injuries in children < 2 yrs old affecting this area. As the child approaches 8–10 yrs of age, the spinal anatomy and therefore injury pattern more closely approximates adult injuries. Although the prevalence of spine injuries is lower in children, clearing the spine becomes more complex due to radiographic differences and the inability to "clinically" clear the cervical spine in young children. In this article, the types of injuries seen in children are discussed, with an emphasis on acute management and clearance of the cervical spine. Treatment options and long-term issues are also discussed. Children's

Hospital Boston, Harvard Medical School, 300 Longwood Avenue, Boston, MA 02115, USA. Mark.proctor@tch.harvard.edu

- Radecki RT and Gaebler-Spira D (1994). Deep vein thrombosis in the disabled pediatric population. *Arch Phys Med Rehabil* 75:248–50. Summary: The incidence of deep vein thrombosis (DVT) in the disabled pediatric population has rarely been studied. The purpose of our retrospective study was to define the incidence in patients younger than 18 years of age who were in a rehabilitation center. We reviewed the charts of 532 children admitted to the center from 1983 through 1987, and found a 2.2% overall incidence of DVT. The largest group of children under 18 of age with documented or suspected DVT was the group with spinal cord injuries (SCI). There were 87 SCI children, 67 of whom were between the ages of 15 and 18. Of the 67, 7 (10%) had DVT: 1 of the 20 SCI children under age 15 had DVT. There were single cases of DVT documented in children with: meningoencephalitis, arteriovenous malformation, closed head injuries, and Guillian-Barre syndrome. We studied the risk involved in treating DVT with heparin and formulated recommendations based on our findings. Rehabilitation Institute of Chicago, Department of Rehabilitation Medicine, Northwestern University Medical School, Chicago, IL.
- ReKate HL, Theodore N, Sonntag VK and Dickman CA (1999). Pediatric spine and spinal cord trauma. State of the art for the third millennium. *Childs Nerv Syst* 15:743–50. Summary: The purpose of this work was to analyze the literature published in English and to review the experience of the Barrow Neurological Institute (BNI) with spine and spinal cord injury (SCI) in children. Standard computerized data bases were queried for information regarding SCI, spinal injury, spinal instability, and spinal cord regeneration to produce a review of the epidemiology, diagnosis, treatment, outcome and directions for future research. We also reviewed our experiences in the management of infants and children with spine injuries and SCIs and with spinal instability from all causes. A total of 132 articles were identified and obtained from the Medical Library at St. Joseph's Hospital and Medical Center in Phoenix, Ariz. and through interlibrary loan. All these articles were read, although not all were used in the final review. A review of all children with SCIs revealed that fractures treated over the past 20 years at the BNI were very rare in preadolescent children, who suffered mostly from ligamentous injury or SCI without radiographic abnormality. A total of 68 children aged 16 years or younger who had been treated over the past 15 years and who had undergone spinal fusions for trauma, congenital anomalies, or tumor resection were identified. Occipitocervical fusion is well tolerated in children as young as 11 months when internal stabilization with a threaded titanium rod is used. Posterior instrumentation, including

pedicle screw fixation, is feasible in children as young as 4 years. Fusion techniques derived from the adult spinal instrumentation experience were found appropriate except for the youngest patients. Fusion in the newborn period was futile in our experience. The adolescent spine does not differ from the adult spine in terms of sensitivity or response to fixation. Children past the neonatal period can be successfully instrumented for spinal stability without apparent long-term sequelae. Related advances are needed in the area of prevention. Long-term advances in spinal cord regeneration can be expected from ongoing basic science investigations. Division of Neurological Surgery, Barrow Neurological Institute, St. Joseph's Hospital and Medical Center, Phoenix, Arizona, USA.

- Reynolds R (2000). Pediatric spinal injury. *Curr Opin Pediatr* **12**:67–71. Summary: Spine injury in children thankfully is still a relatively rare injury. The incidence of pediatric spine injuries has been reported as 2% to 5% of all spine injuries. The biological differences of children make differences in fracture patterns and alter the management necessary for successful treatment. The other factors that affect fracture production and associated injuries are head size relative to the body size, flexibility of the spine and supporting structures, the growth plates, and the elasticity and compressibility of the bone. The majority of compression injuries in children are made up of falls from a height. Spinal injuries in children remain a challenge despite some technical changes in assessment and treatment. University of Southern California, Childrens Hospital, Los Angeles, USA.

- Samallahti P, Kannisto M and Aalberg V (1996). Psychological defenses and psychiatric symptoms in adults with pediatric spinal cord injuries. *Spinal Cord* **34**:669–72. Summary: The psychological defenses and psychiatric morbidity of 30 adults with pediatric spinal cord injury and of 235 community controls were compared several years after the occurrence of the injury. The patient group did not report more symptoms when measured with the Symptom Checklist–90 than the control group, but there were some characteristic features in their use of defenses as measured with the Defense Style Questionnaire. The adaptation process seems to follow a pattern: the greater the length of time since the injury, the less likely were the immature defenses omnipotence–devaluation and regression and the higher were the scores on the mature defense anticipation. It appears that the same result–symptom free adaptation–is first achieved by more immature means but as the adaptation process evolves, the psychological equilibrium can be maintained by mature defenses which do not distort reality. Furthermore, the results that patients with pediatric spinal cord injury scored higher on fantasy (daydreaming) and passive aggression (silent resistance) suggest that

being injured very young may leave some faint, yet permanent psychodynamic traces. University of Helsinki, Department of Psychiatry, Finland.

- Shahar E, Andraus J, Savitzki D, Pilar G and Zelnik N (2002). Outcome of severe encephalomyelitis in children: effect of high-dose methylprednisolone and immunoglobulins. *J Child Neurol* 17:810–4. Summary: Acute encephalomyelitis in children refers to an insult of cortical white matter leading to acute disseminated encephalomyelitis, insult of the spinal cord leading to multifocal myelopathy, or a combined form of encephalomyelitis. We report here the clinical presentations and outcome of 16 children with severe acute encephalomyelitis analyzing the effect of high-dose methylprednisolone or intravenous immunoglobulins, administered separately or in combination. Five children developed acute disseminated encephalomyelitis alone, eight developed severe multifocal myelopathy accompanied in two of them by radiculoneuropathy, and three developed the most severe form of combined encephalomyeloradiculoneuropathy. The indications for treatment with either high-dose methylprednisolone, intravenous immunoglobulin, or a combination of the two were severe acute disseminated encephalomyelitis, visual loss, or severe flaccid weakness accompanied by bladder and bowel incontinence. Overall, 10 children had remarkably responded to high-dose methylprednisolone alone and recovered within 10 days. One patient with severe myelopathy, developing paraplegia, who failed oral corticosteroids completely recovered following intravenous immunoglobulin. Of the isolated acute disseminated encephalomyelitis group, all patients were initially treated with high-dose intravenous methylprednisolone and recovered within 10 days, including visual remission in the child with severe optic neuritis. All six children with solitary severe multifocal myelopathy were treated with high-dose methylprednisolone alone and recovered within the first week. Two patients had severe myeloradiculoneuropathy and were therefore treated with combined high-dose methylprednisolone and intravenous immunoglobulin: one remains paraplegic, whereas the second was ventilated for 3 weeks and recovered after 2 months. The three children with the most severe form of encephalomyeloradiculoneuropathy were treated with combined high-dose methylprednisolone and intravenous immunoglobulin; two remain severely handicapped, of whom one is paraplegic, and the third unexpectedly recovered within 3 months. Therefore, our experience indicates that either high-dose methylprednisolone or intravenous immunoglobulin, given separately or combined, may be efficacious in severe debilitating pediatric-onset acute encephalomyelitis. In children with the most severe form of encephalomyeloradiculoneuropathy, we suggest initially administering high-dose methylprednisolone and intravenous immunoglobulin

combined, given the poorer outcome of our patients with combined severe central and peripheral demyelination. Child Neurology Unit, Meyer Children Hospital, Rambam Medical Center, Haifa, Israel.  
e\_shahar@rambam.health.gov.il

- Shamoun JM, Riddick L and Powell RW (1999). Atlanto–occipital subluxation/dislocation: a "survivable" injury in children. *Am Surg* 65:317–20. Summary: Atlanto–occipital dislocation occurs more often in children due to the laxity of the ligamentous structures anchoring the occiput to the axial skeleton. The mechanism of action usually involves a sudden acceleration–deceleration force on the head of the child. The dislocation usually severs the spinal cord at the foramen magnum, resulting in acute respiratory arrest. We have managed four patients who sustained this injury and arrived at our trauma center with signs of life. Two patients were hemodynamically unstable, had positive diagnostic peritoneal lavage, and underwent splenectomy. Both patients had obvious separation of the occiput and C1 on lateral cervical spine films. Both remained very unstable and died soon after craniotomy. The other two patients were stabilized, and both met criteria for brain death; one family agreed to organ donation. A 5–year analysis revealed 57 pediatric deaths, with 10 patients sustaining atlanto–occipital dislocations (17.5%). Nine of 10 patients sustained other injuries, but in only 2 patients were the injuries immediately life–threatening. With continued improvement in emergency medical systems and pediatric trauma care, we can expect to see more pediatric patients with this injury arriving in trauma centers with signs of life. In our experience, 50 per cent of patients may meet organ donor criteria, and our incidence of this injury (17.5%) reveals atlanto–occipital dislocation as a major contributor to pediatric trauma mortality. University of South Alabama Medical Center, Mobile, USA.

- Smith BT, Mulcahey MJ and Betz RR (2001). An implantable upper extremity neuroprosthesis in a growing child with a C5 spinal cord injury. *Spinal Cord* 39:118–23. Summary: OBJECTIVES: To implement a functional electrical stimulation (FES) hand neuroprosthesis called the Freehand System in a growing child with spinal cord injury (SCI) using extra lead wire to accommodate limb growth, and to evaluate the performance of the Freehand System during the subject's maturation. SETTING: Pediatric orthopedic hospital specializing in SCI rehabilitation. SUBJECT: Ten–year–old female patient with a C5 level SCI. METHOD: The Freehand System was implanted. Eight electrodes were implanted to targeted forearm and hand muscles to provide grasp and release function. The lead wire associated with each electrode was pathed subcutaneously up the arm with 4 cm of extra lead distributed throughout the path to accommodate expected limb growth. All leads were attached to a stimulator placed in the upper chest. Measures of lead

unwinding, limb growth, stimulated muscle strength, and hand function were made at 6 and 16 months after implant. RESULTS: By 16 months post implant, the upper limb growth plates were closed and humeral and radial bone growth combined was 2.7 cm from the time of surgery. For all eight leads, lead unwinding in the upper arm was approximately 1.2 cm and was comparable to humeral bone growth (1.4 cm). Lead unwinding in the lower arm was also measurable for the two electrodes in hand muscles. Six of eight electrodes maintained grade 3 or better stimulated muscle strength throughout the growth period according to a manual muscle test. Of the two other electrodes, one appeared to have lost function due to depletion of excess lead. However, hand function with FES was comparable at 6 and 16 months post implant suggesting that growth did not negatively impact performance with the FES system. Hand function with FES was improved over voluntary hand function as well. Using the Freehand System, a pinch force of approximately 15 N was achieved compared to 1.3 N of voluntary tenodesis pinch force. Scores on the Functional Independence Measure (FIM) increased by 9 points when FES was used as compared to voluntary function. Improvements occurred primarily in eating and grooming. Independence in writing was achieved only with FES. CONCLUSIONS: For this child, hand function with the Freehand System was sustained over the growth period and was a significant functional improvement over voluntary hand function. By using excess lead wire, the Freehand System was successfully implemented before skeletal maturity, affording the child improved hand function earlier than would be otherwise indicated. Research Department, Shriners Hospitals for Children, Philadelphia, Pennsylvania 19140, USA.

- Sun PP, Poffenbarger GJ, Durham S and Zimmerman RA (2000). Spectrum of occipitoatlantoaxial injury in young children. *J Neurosurg* 93:28–39. Summary: OBJECT: Injuries of the occipitoatlantoaxial (Oc–C2) region are the predominant form of cervical injury in children younger than 10 years of age. Magnetic resonance (MR) imaging can be used to visualize directly the traumatic ligamentous and soft-tissue abnormalities of the Oc–C2 region. A retrospective review was undertaken to examine the spectrum of pediatric Oc–C2 injuries seen on MR imaging, their correlation with plain x-ray film and computerized tomography findings, and their clinical course. METHODS: Seventy-one consecutive children younger than 10 years of age underwent cervical MR imaging for evaluation of traumatic injury. Magnetic resonance imaging was used to document abnormalities in 23 children; 20 of these injuries involved the Oc–C2 region. Abnormalities in the Oc–C2 region included disruptions of the musculature, apical ligament, atlantooccipital joint(s), tectorial membrane, and spinal cord. A spectrum of injury with progressive involvement of these structures was seen, ranging from isolated muscular injury to the multiple soft-tissue and ligamentous disruptions with



craniocervical dislocation. Involvement of the tectorial membrane was the critical threshold in the transition from stable to unstable injury. Analysis of plain x-ray films revealed that a novel interspinous C1-2:C2-3 ratio criteria of greater than or equal to 2.5 was predictive of tectorial membrane abnormalities on MR imaging, with 87% sensitivity and 100% specificity. In patients with tectorial membrane abnormalities who underwent immobilization alone, interim platybasia was demonstrated on follow-up MR images. Conclusions. A progressive spectrum of distinct Oc-C2 injuries can occur in young children; the tectorial membrane is a critical stabilizing ligamentous structure in the Oc-C2 complex; and tectorial membrane abnormalities may be identified by a C1-2:C2-3 ratio of greater than or equal to 2.5. Department of Neurosurgery, Children's Hospital of Philadelphia, Pennsylvania, USA.

- Sundel RP (2002). Update on the treatment of Kawasaki disease in childhood. *Curr Rheumatol Rep* 4:474-82. Summary: Intravenous immunoglobulin (IVIG) treatment for Kawasaki disease (KD), first discovered almost 20 years ago, dramatically changed the management and prognosis of the condition. Although standard Japanese Ministry of Health criteria suggest that current treatment is more than 95% effective at preventing coronary artery changes, echocardiographic measurements adjusted for body size, imply a far higher incidence of coronary artery dilatation despite prompt therapy. If one also considers data on chronic alterations in endothelial function after KD, then more effective approaches to the management of acute and recurrent KD are needed. A variety of possible adjunct therapies--most notably high-dose corticosteroids--currently are being studied to determine whether better long-term outcomes may be achieved than with IVIG alone. Department of Medicine, Rheumatology Program, Children's Hospital and Department of Pediatrics, Harvard Medical School, 300 Longwood Avenue, Boston, MA 02115, USA. Robert.Sundel@tch.harvard.edu
- Sylora JA, Gonzalez R, Vaughn M and Reinberg Y (1997). Intermittent self-catheterization by quadriplegic patients via a catheterizable Mitrofanoff channel. *J Urol* 157:48-50. Summary: PURPOSE: Neurogenic bladder due to cervical spinal cord injury is often best managed by clean intermittent catheterization. Limited upper extremity function makes patients with quadriplegia dependent on caregivers for clean intermittent catheterization. The Mitrofanoff umbilical appendicovesicostomy provides easy access to the bladder in patients with all types of access difficulty. We evaluated the Mitrofanoff umbilical appendicovesicostomy in 7 patients with quadriplegia. MATERIALS AND METHODS: Four men and 3 women with cervical spinal cord injury underwent the Mitrofanoff umbilical appendicovesicostomy with appendix (5) or ileum (2). RESULTS: All patients are continent and able to self-catheterize via the umbilical

stoma. In 1 patient with an ileal Mitrofanoff umbilical appendicovesicostomy umbilical incontinence was repaired surgically and stomal stenosis developed in 1, which required stomal revision. All patients use the stoma regularly. Four patients have moved out of care facilities and are living more independently. CONCLUSIONS: The Mitrofanoff catheterizable channel is a valuable option for bladder management in patients with quadriplegia. Clean intermittent self-catheterization allows these patients independent function and facilitates their return to productive lives outside care facilities. Children's Health Care–Minneapolis, Minnesota, USA.

- Tenenbaum S, Chamoles N and Fejerman N (2002). Acute disseminated encephalomyelitis: a long-term follow-up study of 84 pediatric patients. *Neurology* 59:1224–31. Summary: BACKGROUND: Acute disseminated encephalomyelitis (ADEM) is an inflammatory demyelinating disease of the CNS. Few pediatric series have been published, with retrospective and short-term follow-up studies. OBJECTIVES: To describe a cohort of pediatric patients with ADEM and to determine whether clinical and neuroimaging findings predict outcome. METHODS: A prospective study was conducted between March 1988 and July 2000 on 84 consecutive children with ADEM at the National Pediatric Hospital "Dr. J. P. Garrahan." RESULTS: Mean age at onset was 5.3 +/- 3.9 years, with a significant male predominance. Sixty-two patients (74%) had a preceding viral illness or vaccination. Acute hemiparesis (76%), unilateral or bilateral long tract signs (85%), and changes in mental state (69%) were the most prominent presenting features. Four MRI groups were identified: ADEM with small lesions (62%), with large lesions (24%), with additional bithalamic involvement (12%), and acute hemorrhagic encephalomyelitis (2%). Of the 54 children whose CSF samples were analyzed, none showed intrathecal oligoclonal bands. The use of high-dose corticosteroid treatment, particularly IV methylprednisolone, was associated with good recovery and resolution of MRI lesions. After a mean follow-up of 6.6 +/- 3.8 years, 90% of children showed a monophasic course, and 10% a biphasic disease. Eighty-nine percent of patients show at present Expanded Disability Status Scale scores of 0 to 2.5. Eleven percent have disability scores of 3 to 6.5. CONCLUSIONS: Childhood acute disseminated encephalomyelitis is a benign condition, affecting boys more frequently. No association was found between MRI groups and disability. Disability was related to optic nerve involvement at presentation. Even in relapsing cases, the distinction between acute disseminated encephalomyelitis and MS was possible on the basis of long-term clinical and neuroimaging follow-up and the absence of oligoclonal bands in CSF. Department of Neurology, Hospital Nacional de Pediatría Dr. J. P. Garrahan, Buenos Aires, Argentina. solier@ciudad.com.ar

- Triolo RJ, Betz RR, Mulcahey MJ and Gardner ER (1994). Application of functional neuromuscular stimulation to children with spinal cord injuries: candidate selection for upper and lower extremity research. *Paraplegia* 32:824–43. Summary: This paper summarizes the results of screening for participation in research programs involving functional neuromuscular stimulation (FNS). It examines the characteristics of a group of children and teenagers with spinal cord injuries (SCI) identified as potential candidates for FNS as defined by the rigorous inclusion criteria of the research studies. One hundred and thirteen children and teenagers under the age of 20 with cervical, thoracic or lumbar level spinal cord injuries were examined for inclusion in an experimental program of FNS to provide standing, walking, or prehension. Although biased towards adolescents with complete midthoracic and midcervical injuries, the age, sex, injury level, etiology, and neurological status of the sample coincided with previously published reports and consisted predominantly of teenage males injured in motor vehicle or sports related accidents. Approximately half of the individuals examined were physically appropriate for research participation without preparatory intervention. Treatment options to prepare individuals for FNS were identified in 25% of those considered inappropriate at the initial evaluation, indicating that the potential user population of clinical systems may be larger than estimates obtained from research applications. Peripheral denervation was the single most prevalent physical impediment to the application of FNS. Although the incidence of lower motor neuron (LMN) involvement was similar in subjects with tetraplegia and paraplegia, those with cervical lesions more frequently exhibited other medical complications that interfered with the application of FNS. Surgical procedures involving transfer of paralyzed but excitable muscles were identified in almost one third of the candidates with tetraplegia who were excluded due to denervation. Of those physically appropriate, psychological factors eliminated several candidates from consideration. Such concerns may also be addressed with suitable intervention in preparation for the clinical application of FNS. Almost 50% of those appropriate for FNS research elected to participate in the programs, with those declining citing the hospitalization, time and travel commitments as the primary factors influencing their decisions. Results suggest that FNS for standing, walking and hand grasp may be an option for a significant percentage of the pediatric SCI population. Department of Orthopaedic Surgery and Biomedical Engineering, Case Western Reserve University, Cleveland, Ohio.
- Tuite GF, Veres R, Crockard HA and Sell D (1996). Pediatric transoral surgery: indications, complications, and long-term outcome. *J Neurosurg* 84:573–83. Summary: Knowledge of the role and hazards of transoral

surgery has expanded rapidly, but the application of this technique in children has been limited. To assess its usefulness, 27 pediatric patients who underwent transoral surgery between 1985 and 1994 were studied. Transoral surgery was performed for irreducible anterior neuraxial compression at the craniovertebral junction caused by basilar impression, atlantoaxial subluxation with pseudotumor, or chordoma. The patients ranged in age from 3 to 17 years. Symptomatic presentation varied widely, but 89% had significant neurological deficits before surgery. No patient with normal strength deteriorated after surgery. Of the 16 patients with a preoperative motor deficit, nine improved rapidly, three were unchanged, and four significantly worsened in the perioperative period. Those with mobile atlantoaxial subluxation were most vulnerable to surgically related neurological morbidity. Twenty-four patients were alive for long-term follow-up study (average 5.7 years, range 1–9.2 years). Of those with preoperative weakness, nine improved one Frankel grade, four remained the same, and one deteriorated from Frankel Grade D to C. Swallowing and speech worsened in five patients; this occurred only after resection of lesions above the foramen magnum ( $p < 0.05$ ) when rostral pharyngeal disruption resulted in velopharyngeal dysfunction. This study, unlike previous reviews of pediatric transoral operations, leads the authors to suggest that although transoral surgery can be effective, it also carries a significant risk of neurological injury in patients with symptomatic spinal cord compression and it is also associated with long-term swallowing and speech difficulties. Department of Surgical Neurology, The National Hospital for Neurology and Neurosurgery, London, England.

- Tunc B, Oner AF and Hicsonmez G (2003). The effect of short-course high-dose methylprednisolone on peripheral blood lymphocyte subsets in children with acute leukemia during remission induction treatment. *Leuk Res* 27:19–21. Summary: We have previously demonstrated a favorable effect of high-dose steroid in the treatment of children with acute lymphoblastic leukemia (ALL) and acute myeloblastic leukemia (AML). This study was performed to determine the effect of short-course high-dose methylprednisolone (HDMP) treatment on the peripheral blood (PB) T lymphocyte subsets, and blast cells, during remission induction treatment in 23 children with newly diagnosed acute leukemia (16 with ALL, seven with AML). All patients were administered HDMP as a single daily oral dose of 30mg/kg for the first 4 days of induction therapy. The number of PB lymphocyte subsets (CD3, CD4, CD8, CD16+56, CD45RA, and CD45RO) were determined by flow cytometry before and after 4 days of HDMP treatment. While the number of PB blast cells significantly decreased, the absolute number of T lymphocytes expressing CD3, CD4, CD8, CD45RA and the absolute number of CD16+56 (natural killer) cells increased in all patients. We suggest that the beneficial effects of HDMP

in the induction treatment of acute leukemia may occur partly due to an increase in the number of PB T lymphocyte subsets. A study randomly assigning patients to treatment with either conventional therapy or HDMP may provide further information. Faculty of Medicine, Suleyman Demirel University, Isparta, Turkey.

- Turgut M, Akpınar G, Akalan N and Özcan OE (1996). Spinal injuries in the pediatric age group: a review of 82 cases of spinal cord and vertebral column injuries. *Eur Spine J* 5:148–52. Summary: A review of 82 children with spinal cord and/or vertebral column injury treated in our department between 1968 and 1993 showed that 67% of the patients were boys and the average age was 11.4 years. The cause, vertebral level, and type of injury, and the severity of neurological injury varied with the age of the patient. The cause of pediatric injuries differed from that of adult injuries in that falls were the most common causative factor (56%) followed by vehicular accidents (23%). The most frequent level of spinal injury was in the cervical region (57%, 47 patients) followed by the lumbar region (16.5%, 13 patients). In our series, 18% of the patients had complete injury and the overall mortality rate was 3.6%. Eleven children (13%) had spinal cord injury without radiographic abnormality (SCIWORA), whereas 39 (47%) had evidence of neurological injury. Although the spinal injury patterns differed between children and adolescents, the outcome was found to be predominantly affected by the type of neurological injury ( $P < 0.05$ ). Children with complete myelopathy uniformly remained with severe neurological dysfunction; children with incomplete myelopathy recovered nearly normal neurological function. Finally, the authors conclude that most spinal injuries can be successfully managed with nonoperative therapy. The literature is reviewed as to the treatment and outcome of pediatric spinal injuries. Department of Neurosurgery, Adnan Menderes University Medical School, Turkey.

- Van Hala S, Nelson VS, Hurvitz EA, Panzi A, Bloom DA and Ward MJ (1997). Bladder management in patients with pediatric onset neurogenic bladders. *J Spinal Cord Med* 20:410–5. Summary: Our objective was to determine which clean intermittent catheterization (CIC) methods and supplies were used by patients with pediatric onset neurogenic bladders and to relate methodology and materials to reported urinary tract infections. Data were collected via questionnaires distributed by mail and at clinic visits at our university tertiary care outpatient pediatric rehabilitation clinic. Questionnaires were given to 165 patients. Fifty-nine percent were returned (68 patients with myelomeningocele, 27 with pediatric onset spinal cord injury (SCI) and two with other diagnoses). Mean age was 12 years (range 1–27). Fifty-four percent of patients participated in their own CIC. Only two percent used sterile catheterization technique, whereas 98 percent used CIC. A sterile

catheter was employed with clean technique by 22 percent. Catheters were reused by 76 percent. Subjects used a wide ranging number of catheters per month, with a median of 5.3. There was no correlation between the number of urinary tract infections (UTIs) per year and the type of catheter used or the use of prophylactic antibiotics. Compared with patients with myelomeningocele, subjects with SCI were significantly more likely to use sterile catheters ( $p = 0.04$ ),  $> 10$  catheters per month ( $p = 0.01$ ) and gloves ( $p < 0.001$ ). Subjects who used gloves or more catheters were more likely to experience UTI. These data suggest that clean reused supplies are not related to an increased likelihood of UTI and should be considered a way to lower costs in these populations. Department of Physical Medicine & Rehabilitation, University of Michigan Medical Center, Ann Arbor, USA.

- Viccellio P, Simon H, Pressman BD, Shah MN, Mower WR and Hoffman JR (2001). A prospective multicenter study of cervical spine injury in children. *Pediatrics* **108**:E20. Summary: OBJECTIVE: Pediatric victims of blunt trauma have developmental and anatomic characteristics that can make it difficult to assess their risk of cervical spine injury (CSI). Previous reports, all retrospective in nature, have not identified any cases of CSI in either children or adults in the absence of neck pain, neurologic symptoms, distracting injury, or altered mental status. The objective of this study was to examine the incidence and spectrum of spine injury in patients who are younger than 18 years and to evaluate the efficacy of the National Emergency X-Radiography Utilization Study (NEXUS) decision instrument for obtaining cervical spine radiography in pediatric trauma victims. METHODS: We performed a prospective, multicenter study to evaluate pediatric blunt trauma victims. All patients who presented to participating emergency departments underwent clinical evaluation before radiographic imaging. The presence or absence of the following criteria was noted: midline cervical tenderness, altered level of alertness, evidence of intoxication, neurologic abnormality, and presence of painful distracting injury. Presence or absence of each individual criterion was documented for each patient before radiographic imaging, unless the patient was judged to be too unstable to complete the clinical evaluation before radiographs. The decision to radiograph a patient was entirely at the physician's discretion and not driven by the NEXUS questionnaire. The presence or absence of CSI was based on the final interpretation of all radiographic studies. Data on all patients who were younger than 18 years were sequestered from the main database for separate analysis. RESULTS: There were 3065 patients (9.0% of all NEXUS patients) who were younger than 18 years in this cohort, 30 of whom (0.98%) sustained a CSI. Included in the study were 88 children who were younger than 2, 817 who were between 2 and 8, and 2160 who were 8 to 17. Fractures of the lower cervical vertebrae (C5–C7) accounted for 45.9% of pediatric CSIs.

No case of spinal cord injury without radiographic abnormality was reported in any child in this study, although 22 cases were reported in adults. Only 4 of the 30 injured children were younger than 9 years, and none was younger than 2 years. Tenderness and distracting injury were the 2 most common abnormalities noted in patients with and without CSI. The decision rule correctly identified all pediatric CSI victims (sensitivity: 100.0%; 95% confidence interval: 87.8%–100.0%) and correctly designated 603 patients as low risk for CSI (negative predictive value: 100.0%; 95% confidence interval: 99.4%–100.0%). CONCLUSIONS: The lower cervical spine is the most common site of CSI in children, and fractures are the most common type of injury. CSI is rare among patients aged 8 years or younger. The NEXUS decision instrument performed well in children, and its use could reduce pediatric cervical spine imaging by nearly 20%. However, the small number of infants and toddlers in the study suggests caution in applying the NEXUS criteria to this particular age group. Department of Emergency Medicine, SUNY Stony Brook University Hospital, Stony Brook, New York 11794, USA. aviccellio@epo.hsc.sunysb.edu

- Vogel LC and Anderson CJ (2002). Self-injurious behavior in children and adolescents with spinal cord injuries. *Spinal Cord* **40**:666–8. Summary: STUDY DESIGN: A case report of self-injurious behavior in four children and adolescents with spinal cord injuries (SCI). OBJECTIVES: To report a relatively unusual complication of pediatric-onset SCI, focusing on the potential role that dysesthesia may play in self-injurious behavior. SETTING: A Spinal Cord Injury Program in a Children's Hospital in Chicago that serves children from midwestern and south-central United States of America. METHOD: Case reports and literature review. RESULTS: Case reports are presented of four children or adolescents with SCI who exhibited self-injurious behavior. Two of the subjects had symptoms consistent with dysesthesia. The self-injurious behavior in these two subjects and a very young child responded to treatment with anticonvulsants. The self-injurious behavior in the fourth patient was probably the result of poor technique of using his mouth to move his hands, which responded to conservative management including education, occupational therapy and gloves. CONCLUSION: Self-injurious behavior is a relatively unusual complication of pediatric onset SCI, and may be a manifestation of dysesthesia and be responsive to treatment with anticonvulsants. Chief of Pediatrics, Shriners Hospitals for Children, Chicago Associate Professor of Pediatrics, Rush Medical College, Chicago, Illinois, USA.
- Vogel LC, Klaas SJ, Lubicky JP and Anderson CJ (1998). Long-term outcomes and life satisfaction of adults who had pediatric spinal cord injuries. *Arch Phys Med Rehabil* **79**:1496–503. Summary: OBJECTIVE: To

determine long-term outcomes and life satisfaction of adults who sustained pediatric spinal cord injury (SCI). DESIGN: Structured interview of adults who were 25 years or older who had pediatric SCI. SETTING: Community. PARTICIPANTS: A convenience sample of 46 patients from a total of 81 patients who received care in an SCI program: 1 refused participation, 4 died, and 30 were lost to follow-up. MAIN OUTCOME MEASURES: A structured questionnaire including physical, psychosocial, and medical information. The Craig Handicap Assessment and Reporting Technique and two measures of life satisfaction were also administered. RESULTS: Participants were 25 to 34 years old, mean 27 years. Thirty-two had tetraplegia and 14 had paraplegia. Thirty-one were men. Mean years of education was 14. Fifty-four percent were employed, 48% lived independently, and 15% were married. Life satisfaction was associated with education, income, satisfaction with employment, and social/recreation opportunities, and was inversely associated with some medical complications. Life satisfaction was not significantly associated with level of injury, age at injury, or duration of injury. CONCLUSIONS: Individuals who had pediatric SCI, much like adult-onset SCI, have the greatest opportunity for a satisfying adult life if rehabilitation emphasizes psychosocial factors such as education, employment, and long-term health management. Chicago Shriners Hospital for Children, Rush Medical College, IL, USA.

- Vogel LC, Krajci KA and Anderson CJ (2002a). Adults with pediatric-onset spinal cord injuries: part 3: impact of medical complications. *J Spinal Cord Med* 25:297–305. Summary: OBJECTIVE: To determine the impact of medical complications on adult outcomes of individuals with pediatric-onset spinal cord injury (SCI). METHOD: Structured interview including standardized measures. PARTICIPANTS: Individuals who sustained SCI at age 18 years or younger and were 24 years of age or older at interview. OUTCOME MEASURES: A structured interview covering employment, independent living and driving, and marriage. Standardized measures include the Craig Handicap Assessment and Reporting Technique (CHART), the Short Form (SF-12), and the Satisfaction with Life Scale (SWLS). RESULTS: Two hundred sixteen individuals were interviewed, with a mean age at injury of 14 years and a mean age at follow-up of 29 years. Of all the complications, pressure ulcers, severe urinary tract infection (UTI), and spasticity had the greatest impact on adult outcomes. Pressure ulcers were statistically related to all main outcomes. Severe UTI was statistically associated with all the outcomes except for marriage. Spasticity was associated with all the measured outcomes, except for marriage and life satisfaction. Life satisfaction was most significantly associated with severe UTI, pressure ulcers, pain, and respiratory complications. CONCLUSION: Medical complications significantly affect



adult outcomes of individuals with pediatric-onset SCI. Shriners Hospitals for Children, Chicago, Illinois 60707, USA. [lvogel@shrinenet.org](mailto:lvogel@shrinenet.org)

- Vogel LC, Krajci KA and Anderson CJ (2002b). Adults with pediatric-onset spinal cord injury: part 1: prevalence of medical complications. *J Spinal Cord Med* 25:106–16. Summary: OBJECTIVE: To determine the prevalence of medical complications of adults with pediatric-onset spinal cord injury (SCI) and their association with demographic, impairment, and functional limitation factors. METHOD: Structured interview including standardized measures. PARTICIPANTS: Individuals who sustained spinal cord injuries at age 18 years or younger and were 24 years of age or older at interview. OUTCOME MEASURES: Prevalence of medical complications: Urinary tract infections (UTI) requiring intravenous antibiotics or hospitalization (severe UTI), pressure ulcers, hemorrhoids and rectal bleeding, chronic medical conditions, and hospitalizations in the past 3 years. Urinary stones, orchitis or epididymitis, pneumonia, ventilatory assistance, thromboembolism, and latex allergy since injury. Current experience with UTI, bladder and bowel incontinence, bowel program length, constipation or diarrhea, dysreflexia, and hyperhidrosis. RESULTS: Two hundred sixteen individuals were interviewed, with a mean age of injury of 14 years and a mean age at follow-up of 29 years. Most commonly experienced complications were UTI (74%), bowel incontinence (63%), pressure ulcers (44%), autonomic dysreflexia (42%), and respiratory complications (33%). Pressure ulcers were more common in men and latex allergy more common in women. Age at injury was not associated with any of the complications. Older age at interview was associated with orchitis or epididymitis, bowel incontinence, respiratory complications, thromboembolism, and chronic medical conditions; longer duration of injury was associated with these same complications, except for bowel incontinence. Greater neurologic impairment was related to UTI, severe UTI, stones, bowel incontinence, respiratory complications, autonomic dysreflexia, hyperhidrosis, latex allergy, and pressure ulcers. With the exception of latex allergy and UTI, Functional Independence Measure (FIM) scores were associated with the same factors as neurologic impairment. CONCLUSIONS: Medical complications are common sequelae for adults with pediatric-onset SCI. Demographic, impairment, and functional limitation factors are associated with these complications and can be used to identify at-risk individuals. Shriners Hospitals for Children, Chicago, Illinois, USA. [lvogel@shrinenet.org](mailto:lvogel@shrinenet.org)

- Vogel LC, Krajci KA and Anderson CJ (2002c). Adults with pediatric-onset spinal cord injury: part 2: musculoskeletal and neurological complications. *J Spinal Cord Med* 25:117–23. Summary: OBJECTIVE: To determine the prevalence of musculoskeletal and neurological complications of adults with pediatric-onset spinal cord injuries (SCI),

and their association with demographic, impairment, and functional limitation factors. **METHOD:** Structured interview including standardized measures. **PARTICIPANTS:** Individuals who sustained SCI at < or = age 18 years and were > or = age 24 years at interview. **OUTCOME MEASURES:** Prevalence of musculoskeletal and neurological complications: fractures during the past 3 years; scoliosis; heterotopic ossification; hip dislocation or contractures; ankle contractures or pain; shoulder pain; elbow contractures or pain; pain at other sites; neurological deterioration; syringomyelia; and spasticity since injury. **RESULTS:** The 216 individuals who were interviewed had mean age at injury of 14 years and mean age at follow-up of 29 years. Most common complications were pain at any site (69%), spasticity (57%), shoulder pain (48%), scoliosis (40%), hip contractures (23%), and back pain (22%). There were no statistically significant associations between gender and the complications. Whites were more likely than nonwhites to experience pain. Younger age at injury was significantly associated with scoliosis and hip subluxation, and older age at injury was associated with ankle pain and spasticity. Older age at follow-up and longer duration of injury were both associated with elbow and shoulder pain, fractures, and neurological deterioration. Longer injury duration was also associated with hip subluxation and scoliosis. Ankle pain, elbow contractures, and spasticity were more common in those with tetraplegia, and hip contractures were associated with paraplegia. American Spinal Injury Association motor scores were significantly lower in those with elbow contractures and spasticity, and significantly higher in those with hip contractures and neurological deterioration. **CONCLUSION:** Musculoskeletal and neurological complications are common sequelae among adults with pediatric-onset SCI. Demographic, impairment, and functional limitation factors are associated with these complications and can identify at-risk individuals. Shriners Hospitals for Children, Chicago, Illinois, USA. [lvogel@shrinenet.org](mailto:lvogel@shrinenet.org)

- Vogel LC and Lubicky JP (1995a). Ambulation in children and adolescents with spinal cord injuries. *J Pediatr Orthop* **15**:510–6. Summary: The ambulatory status of 76 children and adolescents with spinal cord injuries was studied to delineate the natural history of ambulation and to identify factors predictive of successful ambulation. The type of orthotic used and the degree and duration of ambulation depended on age, completeness and level of the neurologic deficit, and lower extremity contractures. Younger age, L3 or better neurologic levels, incomplete lesions with motor preservation, and absence of lower extremity contractures were associated with functional walking. The psychological advantages of ambulation must be weighed against the cost of orthotics and associated training and the nonfunctional nature of ambulation in the vast majority of individuals with spinal cord injuries. In

addition, the developmental aspects of pediatric spinal cord injuries require changing therapeutic goals at different developmental stages. Shriners Hospital for Crippled Children, Chicago, Illinois, USA.

- Vogel LC and Lubicky JP (1995b). Ambulation with parapodia and reciprocating gait orthoses in pediatric spinal cord injury. *Dev Med Child Neurol* 37:957–64. Summary: The use of parapodia and reciprocating gait orthoses (RGOs) was reviewed in 41 children and adolescents with spinal cord injuries. Compared with users of RGOs, users of parapodia were younger when injured and when the orthotic was first used, were more likely to be household ambulators and to have higher neurological levels, and were unlikely to continue their use of the parapodium after early school age. Hip contractures that required surgical releases or contributed to discontinuation of orthotic usage were present in six of 26 parapodium users and 12 of 22 RGO users. RGOs and parapodia have a limited but important role in management of pediatric spinal cord injury, and should be used in a developmentally based program responsive to the changing needs of children and adolescents. Shriners Hospitals for Crippled Children, Chicago, IL 60635, USA.

- Yetgin S, Tuncer MA, Cetin M, Gumruk F, Yenicesu I, Tunc B, Oner AF, Toksoy H, Koc A, Aslan D, Ozyurek E, Olcay L, Atahan L, Tuncbilek E and Gurgey A (2003). Benefit of high-dose methylprednisolone in comparison with conventional-dose prednisolone during remission induction therapy in childhood acute lymphoblastic leukemia for long-term follow-up. *Leukemia* 17:328–33. Summary: Eight-year event-free survival (EFS) was evaluated in 205 patients with acute lymphoblastic leukemia (ALL), to consider the efficacy of high-dose methylprednisolone (HDMP) given during remission induction chemotherapy between 1 and 29 days. The St Jude Total XI Study protocol was used after some minor modifications in this trial. Patients were randomized into two groups. Group A (n = 108) received conventional dose (60 mg/m<sup>2</sup>/day orally) prednisolone and group B (n = 97) received HDMP (Prednol-L, 900–600 mg/m<sup>2</sup>) orally during remission induction chemotherapy. Complete remission was obtained in 95% of the 205 patients who were followed-up for 11 years; median follow-up was 72 months (range 60–129) and 8-year EFS rate was 60% overall (53% in group A, 66% in group B). The EFS rate of group B was significantly higher than of group A (P = 0.05). The 8-year EFS rate of groups A and B in the high-risk groups was 39% vs 63% (P = 0.002). When we compared 8-year EFS rate in groups A and B in the high-risk subgroup for both ages together  $\leq 2$  or  $\geq 10$  years, it was 44% vs 74%, respectively. Among patients in the high-risk subgroup with a WBC count  $\geq 50 \times 10^9/l$ , the 8-year EFS was 38% in group A vs 58% in group B. During the 11-year follow-up period, a total of 64 relapses occurred in 205 patients. In group A relapses were higher (39%) than in

group B (23%) ( $P = 0.05$ ). These results suggest that HDMP during remission-induction chemotherapy improves the EFS rate significantly for high-risk patients in terms of the chances of cure. Department of Pediatric Hematology, Hacettepe University, Ihsan Dogramaci Children's Hospital, Ankara, Turkey.