COA Paper Session 20: Spine 2 ●

Moderator Raja Y. Rampersaud, ON, and John Street, BC

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Risk Factors for Major Complication Following Surgery for Neuromuscular Scoliosis

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Purpose: Determine the prevalence of complications in neuromuscular scoliosis surgery and to identify risk factors. We hypothesized that patients with smaller preoperative curve magnitudes would have lower complication rates. **Method:** Our Pediatric Orthopaedic Spine Database identified a cohort of 151 consecutive patients with neuromuscular scoliosis who underwent corrective surgery between 1992 and 2005 and had a minimum of 2 years of follow-up. Twenty-two patients (15%) were excluded; 20 patients with a diagnosis of myelodysplasia and two due to death during the follow-up period. Preoperative, operative, and postoperative factors were analyzed for any association with major complications and length of stay (LOS) utilizing stepwise logistic and multiple regression. Only factors with p-values < 0.05 remained in the analysis models. Odds ratios were calculated for significant dichotomous variables and receiver operator characteristic (ROC) curves were created for significant continuous variables. **Results:** There were 79 male and 50 female patients with a mean age at surgery of 13.4 years (range, 6 to 21 years). Eighty-seven patients (68%) underwent posterior spinal fusion (PSF) with segmental spinal instrumentation (SSI). and 42 patients (32%) underwent anterior spinal fusion (ASF) and PSF with SSI. Mean follow-up was 46.4 months (range, 24 to 251 months). There were 45 major complications in 37 patients (29% prevalence). Non-ambulatory status ($p < 0.05$) and a high preoperative Cobb angle ($p < 0.01$) were associated with an increasing prevalence of major complications. Non-ambulatory patients were almost four times more likely to have a major complication (OR of 3.8, $p < 0.05$) in comparison to ambulatory patients. A preoperative Cobb angle ≥ 60 degrees ($p < 0.01$) was the most accurate predictor for an increased risk for major complication.Patients undergoing PSF with SSI only or combined ASF and PSF with SSI on the same day who sustained one major ($p < 0.05$) or two minor ($p < 0.01$) complications had a significantly increased LOS. **Conclusion:** The prevalence of complications following surgery for neuromuscular scoliosis is high. Non-ambulatory status and higher preoperative Cobb curve magnitude are directly associated with an increased risk for major complication and indirectly associated with increased LOS.

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Factors Predictive of Curve Progression and Timing of Definitive Fusion in Early Onset Scoliosis (EOS) Treated by Growing Rod (GR) Construct

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Purpose: To report long-term results (with a minimum follow-up of 13 years) of GR construct [Luque-trolley (LT)] in EOS, to identify factors predictive of curve progression and to establish the timing of definitive fusion. **Method:** The study cohort consisted of 37 patients (22M & 15F) who had primary LT between 1983-1995 were reviewed. Group I: 7 patients had LT alone and Group II: 30 had LT with convex fusion. Cobb at initial presentation, after first surgery, before definitive fusion and at the latest follow-up was recorded. Other radiological curve parameters recorded were rib spinal angle difference (RSAD), end vertebral tilts (EVT), apical vertebral rotation (AVR) and T1-S1 length. Complications with respect to development of junctional/apical kyphosis, implant failure, pseudoarthrosis (PA), sagittal/coronal profile and instrumented spinal segment growth at maturity were evaluated. **Results:** The mean age at definitive fusion for study cohort was 12.5 years. Group I: Mean age at first surgery was 7.4 years (3.3-9.5y). Mean pre-op Cobb angle of primary curve was 600 (310-710) which was corrected to 280 (200-360). They underwent definitive segmental spinal instrumentation(SSI) with fusion at 13.9 years (9.8-15.1y) when the curve had worsened to 480 (400-650). Group II: Mean age at index surgery was 3.6 years (1.6-8.8y). Mean pre-op Cobb of primary curve was 580 (300-900) which corrected to 300 (100-620). 16/30 patients underwent definitive SSI with fusion at 11.5 years (8.5-14.2y) when the curve deteriorated to 600 (530-770). Instrumented segmental spinal growth was 3.2cms (SD±1.45; range 1-5cms). 14/30 maintained their correction till skeletal maturity. JK was observed in 8 cases [proximal(3), distal(2) & apical(3)] which were corrected at the time of definitive SSI. There was a linear relationship between Cobb angle at definitive fusion with concaveRSA and upperEVT. **Conclusion:** Correlation and regression statistics revealed predictive factors of curve progression to be concave RSA (®=0.91 & p=0.001) and upper EVT (®=0.81 & p=0.0004). Patients with high concave RSA and upper EVT should be closely monitored for deterioration. Spinal growth that exceeds the capacity of LT to elongate leads to apical kyphosis. Timing of definitive fusion is influenced by growth velocity, clinico-radiological factors and complications.

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Retrospective Assessment of Distal Foundations in the Correction of Adolescent Idiopathic Scoliosis (AIS)

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Purpose: Determine if one or two pairs of pedicle screws were superior to multiple laminar hooks for the distal foundation segmental in spinal instrumentation (SSI) in the surgical correction of AIS. **Method:** We analyzed 108 consecutive patients identified from our Pediatric Orthopaedic Spine Database (1992-2005) that underwent a posterior spinal fusion (PSF) and segmental spine instrumentation (SSI). There were 3 patient groups: Group 1, one pair of pedicle screws for the distal foundation (n=12); Group 2, two or more pairs of pedicle screws (n=44) and Group 3, multiple hooks only (n=52). The mean age at surgery was 13.5 years, 14.1 years, and 13.0 years, respectively. The major curve was measured perioperatively and at one month, 6 months, 12 months, and 24 months postoperatively and the mean percentage of correction, as well as loss of correction determined. We also analyzed the length of surgery (hours), length of hospitalization and complications. **Results:** The mean preoperative major curve was 52.5 degrees in Group 1, 52. degrees in Group 2, and 48.8 degrees in Group 3. The mean percent postoperative correction (POC%) at 1 month was 67.2, 65.2, and 63.4 % in the 3 groups, respectively (p=0.531). The mean percent post-operative correction (POC%) at 24 month was 55.6% for Group 1, 56.6% for Group 2 and 51.5% for Group 3 (p=0.478). The mean percent loss of correction (LOC%) at 24 months was 3.1%, 2.25%, and 2.9% respectively(p=0.648). One-way ANOVA demonstrated no significant differences in patient age, number of levels fused, length of surgery, or length of hospital stay. There were no implant related complications. **Conclusion:** Hybrid constructs with one or more pairs of pedicle screws and all-hook constructs for distal foundations in SSI provided similar major curve correction, percentage postoperative correction, and are associated with a minimal loss of correction postoperatively. There was no significant difference between length of surgery, hospital stay or complications.

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Thoracoscopic Anterior Instrumentation and Fusion as Treatment for Adolescent Idiopathic Scoliosis: A Systematic Review of the Literature

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Purpose: Traditionally, the accepted treatments for adolescent idiopathic scoliosis (AIS) have included open anterior thoracotomy with instrumentation and posterior spinal fusion and instrumentation. Thoracoscopic instrumentation is a newer technique, whose role remains controversial. This systematic review of the literature aims to better understand thoracoscopic instrumentation as a treatment for AIS and to discuss it in the context of the alternative techniques currently used. **Method:** The most commonly used medical databases (PUBMED, Medline, EMBASE, Cinahl, and the Cochrane library) were searched up to April 2008 using the search terms “VATS”, “thoracoscopic scoliosis” and “thoracoscopic scoliosis

instrumentation". Two reviewers independently performed the literature evaluation. There were no language restrictions. Because the number of randomized controlled trials was anticipared to be small, we included relevant non-randomized trials, observational studies, and uncontrolled studies. **Results:** Eleven studies met the strict inclusion criteria for the systematic review, of which the majority were level III and IV evidence. Four hundred and forty-five cases have been reported, 80% of them female, with the vast majority having a diagnosis of AIS. Similar surgical techniques were used and had a mean operative time of 355 minutes, mean blood loss of 444 ml, and mean hospital stay of 5.1 days. Mean pre-operative curve magnitude was 47.9o; post-operative curve magnitude was 16.3o, with a correction of 62%. Number of levels instrumented was 6.3, pulmonary function testes returned to pre-operative values by 2-years post-operative, and complication rate was 21.6%, including a pulmonary complication rate of 9.2%. SRS questionnaires revealed that patients were satisfied. **Conclusion:** The major drawbacks of the thoracoscopic approach are the operative time and incidence of early pulmonary complications. Advantages include: minimally invasive, less blood loss, short hospital stay, excellent curve correction, few levels fused, good patient satisfaction, and no long term effect on pulmonary function. With appropriate surgeon training, careful patient selection, and precise surgical technique, this technique can offer an acceptable alternative to the more traditional procedures.

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Prospective Cohort Analysis of Primary Pyogenic Infection of the Spine in Intravenous Drug Users

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Purpose: To evaluate the demographics, presentation, treatment and outcomes of spinal infection in a population of Intravenous Drug Users. **Method:** Data on all patients with pyogenic spinal infection presenting to a quaternary referral center was obtained from a prospectively maintain database. **Results:** Over the five-year study period, there were 102 patients treated for Primary Pyogenic Infection of the Spine of which 51 were Intravenous Drug Users (IVDU). Of this IVDU group there were 34 males. Mean age was 43 years (range 25 – 57). Twenty-three had HIV, 43 Hepatitis C and 13 Hepatitis B. All were using cocaine, 26 were also using Heroin and 44 more than three recreational drugs. Thirty patients presented with axial pain with a mean duration of 51 days (range 3-120). Thirty-one were ASIA D or worse with eight ASIA A. Mean Motor Score of patients with deficit was 58.6. Most common ASIA Motor Levels were C4 and C5. Mean duration of neurological symptoms was seven days (range 1-60). Blood parameters on admission were in keeping with sepsis in immunocompromised patients. None had previous surgery for spinal infection. Twenty-sex were receiving IV antibiotics for known spinal infection. 44 patients were treated surgically. 32 had infection of the cervical spine, 9 Thoracic and 3 Lumbar. 22 had a posterior approach alone, 13 had anterior only while 9 required combined.

Mean operative time was 263 mins (range 62 – 742). 13 required tracheostomy. 7 required early revision for hardware failure and 2 for surgical wound infection. Mean duration of antibiotic treatment was 49 days (range 28-116). 26 patients had single agent therapy. 17 had MSSA and 17 MRSA. At discharge 28 patients had neurological improvement (mean 20 ASIA points, range 1-55), 11 had deterioration (mean 13, range 1-50) and 5 were unchanged. There were no in-hospital deaths. At 2 years after index admission 13 patients were dead and none were attending the unit for follow-up. **Conclusion:** Primary pyogenic spinal infection in IVDU's typically presents with sepsis and acute cervical quadriplegia. Surgical management must be prompt and aggressive with significant neurological improvement expected in the majority of patients.

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Comparative Stability of Two C1-C2 Transarticular Screw Salvaging Fixation Techniques

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Purpose: The current gold-standard for atlanto-axial fixation is C1-C2 Transarticular Screw (TS) fixation. In certain cases, the complicated nature of vertebral artery injury could make the application of bilateral transarticular screws impossible. This study biomechanically compares three atlantoaxial transarticular salvaging fixation techniques. **Method:** Nine Fresh ligamentous human cervical spine specimens (C0-C4) were thawed and the tissue surrounding the spine, except the ligaments and discs, was carefully removed. Pure moments were applied to skull in increments of 0.5 Nm from 0 Nm to 2.0 Nm with the help of loading arms, nylon strings and pulleys. The specimens were tested in extension (EXT), flexion (FLEX), left lateral bending (LB), right lateral bending (RB), left axial rotation (LR) and right axial rotation (RR) for all the cases. The positions of the LEDs were recorded using an Optotrak Motion Measurement System (Northern Digital, Waterloo, Ontario, Canada) and was converted into three rotations (flexion/extension, lateral bending and axial rotation) using rigid body kinematic principles in relation to the fixed base. The specimens were tested intact and after type II odontoid fracture, were instrumented and tested with three fixation constructs: 1) C1-C2 TS on right side and C1LMS-C2PS on contralateral side 2) C1-C2 TS on right side and C1LMS-C2IL on the contralateral side and 3) C1-C2 TS on right side with sublaminar wire. **Results:** All of the three instrumented cases significantly reduced motion across C1-C2 segment in all the modes when compared to intact ($P<0.005$, two-tailed unpaired t-test at confidence interval of ninety-five percent) except in extension. TS+C1IM+C2PS is significantly stiffer than TS+ Wire only in axial rotation ($P<0.05$) and equivalent in flexion/extension ($P=0.75$/$P=0.51$) and left/right bending ($P=0.22$/$P=0.58$). TS+C1LM +C2PS is equivalent to TS+C1LM+C2IL in all the loading modes ($P>0.05$). TS+C1LM+C2IL is significantly stiffer than TS+Wire in axial rotation ($P <0.05$) and equivalent in

flexion/extension (P=0.93) and left/right bending (P=0.69/P=0.84). **Conclusion:** This study showed that TS+C1LMS+C2PS fixation is equivalent to TS+C1LMS+C2ILS fixation in all the rotation modes and superior to TS+Wire fixation in axial rotation averaged over all ranges of motion. Also, TS+C1LMS+C2ILS fixation is superior to TS+Wire fixation in axial rotation averaged over all ranges of motion.

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A Prospective Analysis Comparing Preoperative MRI to Diagnose Disruption of the Posterior Ligamentous Complex in Cervical Spine Injury and Intraoperative Findings

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Purpose: The decision of whether or not an injury to the sub-axial cervical spine needs operative management often hinges on the stability of the spine. The posterior Ligamentous Complex (PLC) is one of the primary soft tissue stabilizers of the cervical spine. Fat-saturated T2-wieghted MRI sequences are able to demonstrate soft tissue injury to the cervical spine. No studies to date have assessed the ability of MRI to accurately and reliably demonstrate PLC disruption in the sub-axial cervical spine. **Method:** Forty-nine consecutive patients aged 14-85 years presenting to the two participating institutions with injury between C3 and T1 who required posterior surgery as part of their management were prospectively enrolled in the study. All patients had radiographs, CT, and MRI scans preoperatively, which were reviewed by a Neuroradiologist, and the treating surgeon separately. Their posterior intraoperative findings were then recorded by the treating surgeon and his assistant. Statistical analysis included Spearman's rank order correlation, and Cohen's kappa score. **Results:** There was a moderate level of agreement between the radiologist's interpretation of the preoperative MRI and the surgeon's intraoperative findings for the supraspinous and intraspinous ligaments, (kappa .49 & .48 respectively). A fair level of agreement was found for the ligamentum flavum, left and right facet capsules, and the cervical fascia (kappa scores .31, .30, .30, .39 respectively). **Conclusion:** MRI has a high sensitivity (78.6% to 100%) for detecting cervical PLC injury but a low specificity (53.6% to 75%). On its own MRI is not a useful tool for diagnosing cervical spine PLC injury. The clinician should be aware of the relatively high rate of false positive PLC injury diagnosis with MRI.

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The Prevalence of Spinal Magnetic Resonance Imaging Changes in Surgical versus Non-surgical Patients ? A Retrospective Study

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Purpose: Magnetic resonance imaging (MRI) is the diagnostic imaging modality of choice for spinal disorders. The high prevalence of "abnormal" MRI findings within asymptomatic individuals is well established, however, referrals to spine surgeons are often based on symptomatically discordant or non-surgical MRI "abnormalities". The purpose of this study was to determine the prevalence of typical spine MRI abnormalities among symptomatic surgical candidates (SC) and non-surgical (NS)patients. **Method:** A retrospective cohort study was conducted on 1,585 patients (with a lumbar MRI) seen by a spine surgeon. The cohorts were compared in terms of the total amount, type, severity and number of levels of abnormalities on MRI. All patients were prospectively stratified regarding surgical candidacy. **Results:** There was no difference between the cohorts (n=722-SC / 863-NS) in terms of the total amount of structural abnormalities present (p=0.26). There was no difference in the prevalence of DDD, disc-herniation or previous surgery (p> 0.2). However, there was a higher prevalence of spinal stenosis (0.513 vs. 0.394) and spondylolisthesis (0.263 vs. 0.112) within the SC (p≤0.01). Logistic-regression showed that patients with disc-herniation, stenosis or spondylolisthesis were 1.49, 1.61 and 2.84 times more likely to be SC respectively (p≤0.001). Subjects with a report of severe/large herniation or stenosis were 3.30 and 2.25 times (p<0.001) more likely to be SC respectively. Patients with one-level anomalies were 2.19 times (p<0.0001) more likely to be SC. **Conclusion:** It is hopeful that these results will better enable non-surgeons to more effectively identify and educate patients with a higher likelihood of being surgical candidates.

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Motor Recovery and Health-related Quality of Life in Patients with a Thoracolumbar Spine Injury: Relationship to Neural Axis Level of Injury?Spinal Cord (SCI), Conus Medullaris (CMI), and Cauda Equina (CEI)

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Purpose: To determine whether neural axis level of injury (SCI, CMI, or CEI) is related to motor improvement, as defined by the International Standards for Neurological Classification of Spinal Cord Injury motor score (MS), in patients with a thoracolumbar (T11-L3) spine injury. **Method:** Fifty-three patients who sustained a neurological deficit secondary to a thoracolumbar spinal injury between 1995-2003 had injury details and MS collected prospectively. An independent evaluation determined the follow-up MS and SF-36 generic health-related quality of life (HrQOL) at a mean of 6.6 (SD 2.5) years post-injury. All patients had an MRI reviewed by a spine surgeon and neuroradiologist to determine the location of their conus medullaris and precise level of neural axis injury. **Results:** Nineteen patients (37%) had SCI, 20 (39%) had CMI, and 12 (24%) had CEI, while two could not be classified. Patients with SCI improved their MS by an average 7.0 motor points (SD 9.8); CMI improved 11.9 (SD 11.8); and CEI improved 16.8 (SD 16.0). This trend did not achieve statistical significance (p=0.09). Multivariate

analyses demonstrated that initial MS had a significant interaction with neural axis level of injury with respect to the primary outcome. Specifically, CEI showed the greatest improvement in MS only when the initial MS was less than 75. Absence of initial anal sensation, a fracture-dislocation injury type and increasing time to surgery were all statistically associated with less improvement in MS. The mean follow-up SF-36 physical component score (PCS) was 37.3 (SD 10.1) and the mean mental component score (MCS) was 51.4 (SD 11.8). There was no significant difference in mean PCS and MCS for varying levels of neural axis injury. **Conclusion:** Patients with a CEI demonstrated the most improvement in MS, while absent anal sensation, a fracture-dislocation, and long delay to surgery were poor prognostic indicators for motor recovery. The HrQOL outcomes did not vary with neural axis level of injury. The results of this study assist in determining a prognosis for patients that sustain these common injuries. Future research should focus on how specific pre- and peri-operative variables affect outcomes in patients with neurological deficits secondary to thoracolumbar injuries.

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Demographics of Traumatic Spinal Cord Injury in British Columbia. A Prospective Cohort Analysis of 10 Years

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Purpose: Prospective Observational Population Study to describe the incidence, demographics and pattern of spinal cord injury in British Columbia, Canada, for 10 years to 2004. **Method:** Systematic analysis of prospectively collected spine registry data (Vertebase) at Vancouver General Hospital, B.C., Canada from 1995-2004. **Results:** During the 10-year study period the 938 patients were admitted with a traumatic spinal cord injury. The Annual Population-Standardized Incidences ranged from 19.94 to 27.27 per million, with a median incidence of 23.34/million and with no significant change over the study period. The mean age was 39.7 years (34.73 in 1995 and 42.1 in 2004, $p<0.05$) with a range of 16-92 years. 79.74 % were males. 48.2% of patients were AISA A on admission, of which 48% were quadraparetic. The most common levels of spinal cord injury were C5 (17.3%), C6 (10%), T1 (9.4%), T12 (5.8%). The Mean ASIA score was 50.22 with a range from 0-100. 19.8% of patients had a GCS£13. The mean ISS was 26.02, range of 0 - 75. Motor vehicle collisions and falls were responsible for 59% and 30% of admissions respectively. Mean length of in-hospital stay was 34 days, ranging from 1 – 275 days. In hospital mortality rate was 2.9%. ASIA Grade, Total Motor Score and anatomical level of injury all correlated directly with Length of stay ($p<0.0001$). **Conclusion:** Acute Traumatic Spinal Cord Injury remains a major cause of significant morbidity among young males.The incidence appears to be increasing in the elderly. Modern multidisciplinary care has greatly reduced the associated acute mortality. Despite multiple prevention strategies the Annual Population-Standardized Incidence remained unchanged over the study period.