

Canadian Journal  
of **Surgery**

Journal canadien  
de **chirurgie**

Vol. 59 (3 Suppl 2) June/juin 2016  
DOI: 10.1503/cjs.006916

# **Canadian Spine Society**

**16th Annual Scientific Conference**

**The Fairmont Château Whistler**

**Whistler, British Columbia**

**Feb. 24–27, 2016**

**Abstracts**



The Canadian Spine Society is a collaborative organization of spine surgeons advancing excellence in research, education and patient care.

**Accreditation:** This event is an accredited group learning activity (Section 1) as defined by the Maintenance of Certification Program of the Royal College of Physicians and Surgeons of Canada, approved by The Canadian Orthopaedic Association.

**Course objectives:** The Annual Scientific Conference of the Canadian Spine Society provides a contemporary review of spine surgery and spine care in Canada. The conference is a joint meeting of the Canadian Spine Society and the Canadian Paediatric Spine Society that encompasses a full range of spinal problems and current solutions. This year the focus ranged from the best means of triaging back pain patients to avoid unnecessary surgical intervention to the complication of postoperative spinal infection. Pediatric presentations included the ongoing study of home-based pain management following scoliosis surgery and the status of the national spine registry. The program offered a carefully constructed mix of didactic lectures, research updates and interactive symposia, and an opportunity to obtain valuable continuing medical education while engaging in a vibrant exchange of ideas and points of view

**Conflicts of interest:** Available for all speakers who presented abstracts at the 16th Annual Scientific Conference of the Canadian Spine Society.

**1.01: Do lumbar decompression and fusion patients recall their preoperative status? Recall bias in patient-reported outcomes.** *Ilyas Aleem\**, *Jonatban Duncan\**, *Amin Ahmed\**, *Jason Eck\**, *John Rhee†*, *Bradford Currier\**, *Abmad Nassr\**. From the \*Mayo Clinic, Rochester, Minn.; and the †Emory Hospital, Atlanta, Ga.

**Background:** To characterize the accuracy of patient recall of preoperative symptoms in a cohort of lumbar spine surgery patients. **Methods:** We analyzed consecutive patients undergoing lumbar decompression or decompression and fusion for lumbar radiculopathy by a single surgeon over a 4-year period. Using standardized questionnaires, we recorded back and leg numeric pain scores (NPS) and ODI preoperatively and asked patients to recall their preoperative status at a minimum of 1 year following surgery. We then statistically compared actual and recalled preoperative scores. Multivariable linear regression was used to identify factors that had an impact on recollection. Pearson correlation coefficients quantified relations between recalled and actual scores. **Results:** Sixty-two patients with a mean age of 66.1 years (55% female) were included. All patients showed significant improvement in back pain (mean difference [MD] -3.2, 95% CI -4.0 to -2.4,  $p < 0.01$ ), leg pain (MD -3.3, 95% CI -4.3 to -2.2,  $p < 0.01$ ), and disability (MD -25.0%, 95% CI -28.7 to -19.6,  $p < 0.01$ ) postoperatively. Patient recollection of preoperative status was significantly worse for back pain (MD +2.3, 95% CI 1.5-3.2,  $p < 0.05$ ), leg pain (MD +1.8, 95% CI 0.9-2.7,  $p < 0.05$ ) and disability (MD +9.6%, 95% CI 5.6-14.0,  $p < 0.05$ ). This was maintained across age, sex, and symptom duration. The magnitude of recall bias was moderate to severe and exceeded the minimal clinically important difference in more than 67% of patients for back and leg pain. No significant correlation between actual and recalled scores with regards to back ( $r = 0.18$ ) or leg pain ( $r = 0.24$ ) and only moderate correlation with disability ( $r = 0.44$ ) was seen. **Conclusion:** Significant recall bias of preoperative symptoms exists in patients undergoing spine surgery, potentially limiting accurate assessment and interpretation of postoperative assessment.

**1.02: Trends and costs of lumbar fusion and disc replacement surgeries in Ontario: a population-based study.** *Yan Xu*, *David Yen*, *Ana Johnson*. From Queen's University, Kingston, Ont.

**Background:** Lumbar fusion (LF) surgery has become widely used for the treatment of degenerative conditions of the spine, despite limited evidence for its efficacy and cost-effectiveness. In the United States, LF rates have risen rapidly, approaching those of hip and knee replacements. We sought to determine the longi-

tudinal utilization rates and direct medical costs associated with LF procedures in Ontario, Canada's largest province, and to compare these with rates of total hip and knee replacements. **Methods:** Using administrative data, we conducted a time-series analysis of rates and costs associated with LF for degenerative spine conditions between 1993 and 2011 in Ontario. We stratified surgical rates and costs by age deciles. Rates of hip and knee replacements were also evaluated over the same period and compared with those of LF. **Results:** Over the 18-year period, rates of LF increased from 6.16 to 14.13 per 100 000 Ontarians ( $p < 0.05$ ), though well below hip and knee replacement rates. Age groups experiencing the highest LF utilization were 60-69 and 70-79 years. In 2011, direct medical costs and professional fees associated with LF exceeded \$24 million. Spinal stenosis and spondylolisthesis were the primary diagnoses in 42.9% and 26.6% of cases, respectively. **Conclusion:** Rates of LF surgery for degenerative spine conditions more than doubled from 1998 to 2011, with spinal stenosis and spondylolisthesis comprising the most common primary diagnoses. Given its unfavourable cost-effectiveness for the treatment of these 2 conditions and its large and growing budgetary impact, the uptake of LF requires increased scrutiny.

**1.03: Ontario's Inter-professional Spine Assessment and Education Clinics (ISAEC): patient, provider and system impact of an integrated model of care for the management of LBP.** *Y. Raja Rampersaud†*, *Andrew Bidos†*, *Sue Schultz‡*, *Caroline Fanti†*, *Barry Young†*, *Brian Drew†§*, *David Puskas¶*, *David Henry‡*. From the †University Health Network, Toronto, Ont.; the ‡Inter-professional Spine Assessment and Education Clinics, Hamilton, Ont.; §the Institute for Clinical Evaluative Sciences, Toronto, Ont.; ¶Hamilton General Hospital, Hamilton, Ont.; and the ¶Thunder Bay Regional Health Sciences Centre, Thunder Bay, Ont.

**Background:** The objectives of this study are to determine the impact of ISAEC on 1) patient-reported satisfaction and outcome; 2) primary care provider (PCP) satisfaction and knowledge transfer; and 3) utilization of spinal imaging from the perspective of the health care system. **Methods:** 1) Mixed-methods study for patient and provider evaluation (patient-reported outcomes measures and surveys). 2) Institute for Clinical Evaluative Sciences (ICES) administrative data analysis comparing spine imaging test ordering by ISAEC and non-ISAEC physicians. **Results:** From November 2012 to May 2015, 3347 patients have been assessed. Mean wait time for primary assessment was 10 days. Most patients (68%) were diagnosed with back-dominant pain. Most presentations (68%) were considered complex (e.g., positive for psychosocial

factors (52.2%). Patient satisfaction ( $n = 1922$ ) was 99%, and 95% felt they understood their condition better. For 417 patients enrolled in a longitudinal study, significant reduction in ODI was observed at 6 months (baseline 36%, 6 months 26%). At 4 and 12 months into the program, enrolled PCPs (134 of 220) on average showed a 2-fold increase in their confidence managing LBP (assessment and management, referral for imaging and specialist consultation). In total, 97% of PCPs reported overall satisfaction with the ISAEC model of care and felt that ISAEC services would be useful to all PCPs. Within the ISAEC network of providers, specialist referral appropriateness was 96% and < 4% of ISAEC patients have gone on to specialist interventions. Compared with non-ISAEC physicians, the overall annual costs for all LBP-related diagnostic imaging ordered by ISAEC-physicians fell 28% in year 1 and an additional 5% in year 2. This translates to an annual estimated per-physician cost avoidance of \$3150 and \$4175 in years 1 and 2, respectively. **Conclusion:** A shared-care model of care for LBP provides significant multidimensional impact on patients, providers and the health care system.

**1.04: Validation of the self-administered online assessment of preferences (SOAP) utility elicitation tool.** *Markian Pabuta\**, *Aaron Frombach\**, *Gunita Mitera†*, *Doug Coyle\**, *Joel Werier\**, *Eugene Wai\**. From the \*University of Ottawa, Ottawa, Ont.; and the †University of Toronto, Toronto, Ont.

**Background:** Quality-adjusted life-years (QALY) quantify the net morbidity and mortality experienced by patients in a single number. QALYs are computed using “utilities,” which are a measure of preference for a clinical outcome. If a disease process has not been studied using general health surveys, utilities can be obtained using the standard gamble (SG) method. There have been no reports in the literature of the validity and reliability of SG utilities. We sought to determine the validity and reliability of SG utilities for metastatic epidural spinal cord compression (MESCC). **Methods:** We developed an electronic self-administered SG utility elicitation tool (SOAP). MESCC health state descriptions were developed from key domains identified by the European Organisation for Research and Treatment of Cancer (EORTC) MESCC working group, which included ambulation, continence, pain, independence, and “other symptoms.” Health states were constructed to have 1, 3 or 5 dysfunctional domains. Individuals accompanying patients to the emergency department waiting room of a tertiary care hospital were recruited. Participants made SOAP MESCC health state valuations in the waiting room and 48 hours later at home. Validity was measured by logical consistency. Reliability was measured using 95% limits of agreement and the intraclass correlation coefficient (ICC). **Results:** Of 81 participants, 55 (68%) completed the retest. Of these 55 participants, 39 (71%) provided a valid response twice. For the single, triple and fully dysfunctional health states, 95% limits of agreement were:  $0 \pm 0.32$ ,  $0 \pm 0.25$ ,  $0 \pm 0.38$ ; the ICCs were 0.765, 0.799 and 0.558. **Conclusion:** The validity of responses using the SOAP tool is greater than that for the survey used to derive Canadian EQ-5D weights. Responses for non-fully dysfunctional health states show substantial reliability. Therefore the SOAP tool has excellent psychometric properties and can be used for future study of MESCC and potentially for other disorders.

**1.05: Performance indicators in spine surgery: a systematic review.** *Godefroy Hardy St-Pierre*, *John Hurlbert*. From the University of Calgary, Calgary, Alta.

**Background:** The Patient Protection and Affordable Care Act has given significant traction to the idea that health care must provide value to the patient through the introduction of hospital value-based purchasing. This systematic review was also meant to elucidate how performance indicators are currently used in clinical spine surgery, if at all. **Methods:** MEDLINE, CINAHL Plus, EMBASE and Google Scholar were searched for studies reporting the use of performance indicators specific to spine surgery. The search was further broadened by investigating the grey literature, including reports by the American College of Surgeons (ACS), the National Quality Forum (NQF), the National Institute for Health and Care Excellence (NICE), the National Health Service (NHS), the Joint Commission, the Centers for Medicare and Medicaid (CMS), and the Surgical Care and Outcomes Assessment Program (SCOAP) of the Foundation for Health Care Quality. **Results:** In total, 865 citations were found across databases. A total of 26 full text articles and reports were retrieved and reviewed. No performance indicators were identified for 3 reasons. First, outcome data without an established standard are more appropriately termed a metric rather than a performance indicator: a widely accepted standard has yet to be established for spine surgery outcomes. Second, most of the retrieved articles had unclear exclusion criteria and little or no risk adjustment associated with their reported outcomes. Third, most articles simply reported the current performance without mentioning a target or expectation. On a positive note, our review revealed a relative consensus among the spine surgery community concerning the outcome metrics to be used in the crafting of performance indicators. The visual analogue scale (VAS), ODI, NDI, the EQ-5D and the SF-36 and its derivatives were almost ubiquitous throughout the literature. **Conclusion:** The science of performance measurement applied to spine surgery is still in its infancy. Current performance metrics used in clinical settings require refinement to become performance indicators.

**1.06: Inter-professional Spine Assessment and Education Clinics (ISAEC): a networked model of care with changes to referral population profile and reduced surgical wait-times.** *Eric Crawford\**, *Robert Ravinsky\**, *Andrew Bidos†*, *Y. Raja Rampersaud\*†*. From the \*Divisions of Orthopaedic Surgery and Neurosurgery, Department of Surgery, University of Toronto, Toronto, Ont.; the †Toronto Western Hospital, University Health Network, Toronto, Ont.; and the †Spine Program, Krembil Neuroscience Centre, Toronto Western Hospital, University Health Network, Toronto, Ont.

**Background:** The primary objective of this study is to determine the effect of ISAEC on referral population profile and wait times for surgical consultation and surgery. **Methods:** Patients assessed through ISAEC were compared with a cohort undergoing traditional triage and clinical assessments (TTCA). A retrospective review of prospectively collected data from a single surgeon from the ISAEC network was performed. Data are reported as medians with interquartile ranges (M; IQR). **Results:** From November 2012 to August 2015, 1585 patients were assessed through ISAEC in Toronto, of which 271 patients (17.1%) were referred for and underwent surgical consultation. Prior to ISAEC, the senior

author screened patients referred from primary care, with 66.6% of referrals that were deemed possibly surgical accepted for consultation (TTCA). Time from referral to surgical consultation was significantly reduced ( $p < 0.001$ ) for patients assessed through ISAEC (64; 48–97 d,  $n = 271$ ) compared with the TTCA group (144; 110–264 d,  $n = 318$ ). Patients assessed through ISAEC (52; 39–64 yr, 56.1% male, 92.5% leg-dominant pain) were younger, more likely to be male and more likely to have a leg-dominant pattern of pain compared with TTCA (60.7; 49–70 yr, 46.5% male, 65.9% leg-dominant pain). For those patients proceeding to surgery, time from referral to surgery was also significantly reduced ( $p < 0.001$ ) for patients assessed through ISAEC (176; 131–307 d,  $n = 59$ ), compared with the TTCA group (376; 297–555 d,  $n = 105$ ). As a result of different diagnostic profiles, the majority (58.2%) of ISAEC patients underwent microdiscectomy, whereas the majority (89.5%) of TTCA patients underwent lumbar spine decompression with or without instrumentation. **Conclusion:** A comprehensive shared-cared model of care for LBP with networked providers and alignment across the continuum of care resulted in sustained reduced wait times for surgical consultation and surgery. Additionally, setting a priori referral criteria can result in the desired surgical practice profile. Future research should focus on the cost-effectiveness of ISAEC from a societal perspective.

**1.07: Improving spine surgical access, appropriateness and efficiency in metropolitan, urban and rural settings.** *Mohammad Zarrabian\**, *Andrew Bidos†*, *Caroline Fanti‡*, *Barry Young§*, *Brian Drew¶*, *David Puskas‡*, *Raja Rampersaud\**. From \*Divisions of Orthopaedic Surgery and Neurosurgery, Department of Surgery, University of Toronto, Toronto, Ont.; the †University Health Network, Toronto, Ont.; the ‡Thunder Bay Regional Health Sciences Centre, Thunder Bay, Ont., the §Inter-professional Spine Assessment and Education Clinics, Hamilton, Ont.; and the ¶Division of Orthopaedic Surgery, McMaster University, Hamilton, Ont.

**Background:** The Inter-professional Spine Assessment and Education Clinics (ISAEC) were developed to improve primary care assessment and management of patients with persistent or recurrent low back-related symptoms. In addition, adaptive ISAEC processes aim to improve the appropriateness of spine investigations and specialist referrals across different regions with distinct system and geographic barriers. The purpose of this study is to determine the effect of ISAEC on access for surgical assessment, referral appropriateness and efficiency in rural (northern), urban and metropolitan settings. **Methods:** Prospective data were retrospectively reviewed from networked ISAEC surgical clinics in Thunder Bay, Hamilton, and Toronto. Wait times for surgical assessment, referral-related MRI, appropriateness of referral and proportion proceeding to surgical management were recorded at each site. **Results:** Overall 386 patients were referred for surgical assessment. Average wait time for surgical assessment was 5.4 weeks, 4.3 weeks, and 2.2 weeks at the metropolitan, urban, and rural centres, respectively, compared with greater than 5–6 months pre-ISAEC. Referral MRI utilization for the group decreased by 31% when compared with previously published Canadian Spine Society (CSS) data. Of the patients referred for formal surgical assess-

ment 80% were deemed to have leg-dominant pain and 96% were deemed appropriate surgical referrals (i.e., had a presentation that was amenable to surgical intervention). The proportion of patients who elected to undergo surgery varied between 25% and 66%. Comparatively, CSS data demonstrated that 82% of spine surgeons reported a proportion less than 20%. **Conclusion:** A networked, shared-care model of care for patients with low back-related symptoms significantly improved access for surgical assessment and management recommendations despite varying geographic practice settings and barriers. The greatest reductions were noted in the rural setting. In addition, significant improvements in referral appropriateness and efficiency (imaging utilization and surgical conversion rate) were achieved, compared with historical reports across sites.

**1.08: Reliability of the spine CPR score among emergency physicians.** *Godefroy Hardy St-Pierre*, *Michael Yang*, *John Hurlbert*, *Ken Thomas*. From the University of Calgary, Calgary, Alta.

**Background:** The Spine Clinical Pathological Radiological (CPR) score is the third iteration of the Calgary Spine Severity Score. Attempted validation of that initial system led to further modification published in October 2015. This score separates spine referrals into 4 time classes: routine, priority, urgent and emergent. It stratifies patients according to clinical, radiological and pathological findings. We aimed to find out whether the Spine CPR score had good interobserver reliability among ER physicians as well as validity, compared with a spine surgeon standard. **Methods:** We crafted 15 clinical vignettes accessible online joined with the Spine CPR score. Twenty emergency department (ED) physicians at 1 centre were asked to score each vignette from 1 to 5 in each category respectively — clinical, pathological and radiological. A spine surgeon was asked to do the same. Total scores were computed and associated with their respective time class. Interobserver reliability was assessed with Fleiss  $\kappa$ . Validity was assessed by the average Cohen  $\kappa$  between the average score of the ED physicians compared with the spine surgeon standard. **Results:** Fleiss  $\kappa$  between the ED physicians was 0.805, corresponding to an excellent level of agreement on the Landis and Koch grading system. Overall average level of agreement was 91%. Similarly, the average Cohen  $\kappa$  between the average score of the ED physicians compared with the spine surgeon standard was 0.849, also corresponding to an excellent level of agreement. Of note, agreement was 100% on all 4 vignettes presenting situations classified as emergent: cauda equina, epidural abscess, rapidly progressive myelopathy and unstable fracture associated with a spinal cord injury. The vignette with the lowest agreement at 36% was a tethered cord with a stable myelopathy. **Conclusion:** The Spine CPR score shows excellent interobserver reliability and validity among ED physicians.

**1.09: Deriving a clinical prediction model for degenerative spine disorders.** *Michael Yang*, *Godefroy Hardy St-Pierre*, *Stephan Duplessis*. From the University of Calgary, Calgary, Alta.

**Background:** Surgeons base their decision-making on many variables, including the undefinable clinical acumen. Trying to define which preoperative variables correlate with offer of surgical treatment, we aimed to identify low- and high-risk groups of patients by creating a clinical prediction model. **Methods:** We performed

retrospective analysis of prospectively collected data at the Foothills Medical Centre on 1371 patients from 2009 to 2014. In total, 231 variables were collected under the headings patient characteristics (age, height, weight, BMI, etc.), comorbidities, past surgeries and injuries, pain descriptors, conservative management, functional indicators, occupational variables, visual analogue scale (VAS) back and leg, PDQ-9 and SF-12. A decision analysis model was used, with logistic regression analysis for the odds of having surgery based on preoperative factors. **Results:** We performed multivariate logistical regression analysis, which revealed 5 variables leading to a convergent model: sitting tolerance > 2 hours (OR 9.42), prior spine operation (OR 5.16), spine injections (OR 3.24), unlimited walking distance (OR 0.03) and walking distance > 1 mile (OR 0.06). Overall model accuracy was 81%, with area under the curve at > 0.84 approaching excellence (0.90). All other variables were nonsignificant. **Conclusion:** Direct functional metrics dominate the decision-making process overshadowing traditional scales, such as the VAS, PDQ-9 and SF-12. Sitting tolerance is possibly a good proxy measure differentiating back from leg pain. Prior spine operation possibly increases the probability of structural abnormality deemed causative of the presenting symptom. Spine injections are used and trusted as a diagnostic tool. Further statistical testing is required to refine this model.

**1.10: Development of validated computer-based preoperative predictive model for reaching ODI MCID with 86% accuracy based on 198 ASD patients with 2-year follow-up.** *Justin Scheer<sup>\*</sup>, Tamir Ailon<sup>†</sup>, Justin Smith<sup>‡</sup>, Christopher Shaffrey<sup>§</sup>, Eric Klineberg<sup>§</sup>, Frank Schwab<sup>¶</sup>, Christopher Ames<sup>\*\*</sup>, International Spine Study Group<sup>††</sup>.* From <sup>\*</sup>University of California San Diego, San Diego, Calif.; the <sup>†</sup>University of British Columbia, Vancouver, B.C.; the <sup>‡</sup>University of Virginia, Charlottesville, Va.; the <sup>§</sup>University of California Davis, Davis, Calif.; the <sup>¶</sup>Hospital for Special Surgery, New York, N.Y.; the <sup>\*\*</sup>University of California San Francisco, San Francisco, Calif.; and the <sup>††</sup>International Spine Study Group.

**Background:** Surgical correction of adult spinal deformity (ASD) results in significant improvement in patients' disability as measured by ODI with the goal of reaching at least 1 minimal clinically important difference (MCID). However, it remains unknown what the specific drivers behind reaching MCID are. This study attempts to develop a preoperative predictive model to identify patients likely to reach ODI MCID. **Methods:** Inclusion criteria: age ≥ 18, ASD. Forty-three variables were included in the initial training of the model and included demographic data, comorbidities, modifiable surgical variables, baseline health-related quality of life (HRQoL) and coronal and sagittal radiographic parameters. Patients were grouped by meeting at least 1 ODI MCID or not at 2-year follow-up. An ensemble of decision trees was constructed using the C5.0 algorithm with 5 different bootstrapped models. Internal validation was accomplished via a 70:30 data split for training and testing each model, respectively. Final predictions from the models were chosen by voting with random selection for tied votes. Overall accuracy and the area under a receiver operator characteristic curve (AUC) were calculated. **Results:** In total, 198 patients were included, (109 MCID, 89 not MCID). The overall model accuracy was 86.0% correct, with an AUC of 0.94, indicating a very good

model fit. Eleven variables were determined to be the top predictors (importance > 0.90) of MCID outcome and included (in decreasing importance): sex, SRS Activity, back pain, sagittal vertical axis (SVA), PI-LL, primary versus revision, T-1 spinopelvic inclination (T1SPI), ASA grade, T-1 pelvic angle (T1PA), SRS Pain, and SRS Total. **Conclusion:** A successful model (86% accuracy, 0.94 AUC) was built predicting reaching ODI MCID. Most of the important predictors were not modifiable surgically, indicating that the baseline clinical and radiographic status of the patient is a critical factor for reaching ODI MCID. This model can set the groundwork for preoperative point of care decision-making and better education for expected outcomes for patients undergoing ASD surgery.

**1.11: Validation of the spine CPR score.** *Godefroy Hardy St-Pierre<sup>\*</sup>, Michael Yang<sup>\*</sup>, John Hurlbert<sup>\*</sup>, Ken Thomas<sup>\*</sup>, Andrew Nataraj<sup>†</sup>.* From the <sup>\*</sup>University of Calgary, Calgary, Alta.; and the <sup>†</sup>University of Alberta, Edmonton, Alta.

**Background:** The Spine Clinical Pathological Radiological (CPR) score is the third iteration of the Calgary Spine Severity Score. This triage score is 12 years in the making. This score separates spine referrals into 4 time classes: routine, priority, urgent and emergent. It stratifies patients according to clinical, radiological and pathological findings. We aim to validate the Spine CPR score. **Methods:** We applied the Spine CPR to an unselected sample of patients from the Foothills Medical Centre between April 2014 and September 2014; it was the same time period the second iteration of the CSSS was derived from an Edmonton data set. Variables collected were elective/emergent operation; time to operating room (OR); and clinical, pathological and radiological CPR. We compared the time to OR predicted by the Spine CPR in 1 of its 4 categories (routine > 6 mo = CPR 3–5, priority < 6 mo = CPR 6–8, urgent < 1 mo = CPR 9–11, and emergent < 1 wk = CPR 12–15) with the actual time to OR and corresponding time class. The current data set was compared with the prior Edmonton data set via analysis of variance (ANOVA). **Results:** In total, 859 patients were analyzed. Of these, 812 had sufficient information available to be scored. Forty-nine were a mismatch with the actual time to OR for an accuracy of 93%. The Spine CPR score overestimated the urgency in 37 cases and underestimated it in 12 cases, all within 1 time class. Average CPR scores were 3.31, 1.85 and 2.69, respectively, with an average Spine CPR score of 7.92. This was no different from the Edmonton data set via ANOVA ( $p = 0.34, 0.42, 0.091, 0.14$ ). **Conclusion:** The Spine CPR score is an accurate and easy-to-use validated triage score. Further statistical testing is required to ensure that the derivation and validation data set are comparable.

**1.12: Can ultrasound detect curve progression of scoliosis without ionizing radiation?** *Edmond Lou<sup>†</sup>, Rui Zheng<sup>\*</sup>, Doug Hill<sup>†</sup>, Marc Moreau<sup>\*</sup>, Douglas Hedden<sup>\*</sup>, Sarah Southon<sup>†</sup>.* From the <sup>\*</sup>University of Alberta, Edmonton, Alta.; and <sup>†</sup>Alberta Health Services, Edmonton, Alta.

**Background:** Ultrasonography (US) has been validated to reliably and accurately measure coronal curvature of children with adolescent idiopathic scoliosis (AIS). The average US measurement difference for 107 AIS curves was  $2.7^\circ \pm 1.9^\circ$  compared with radiographic Cobb angles. However, the sensitivity of US

measurements is still questioned in monitoring nonprogressive cases of children with AIS. **Methods:** Sixty-five participants (54 female, 11 male, mean age  $14.7 \pm 1.9$  yr) were consented and recruited. All participants were diagnosed with AIS; had no surgical treatment before participation; had no in-brace radiographs in both previous and current exams, and the major Cobb angle was less than  $45^\circ$  in the previous radiograph. The standing postero-anterior radiograph and US spine were obtained during the regularly scheduled scoliosis clinic. To simulate a clinical practice to detect possible curve progression, the current US measurement was compared with the previous known radiograph measurement. To determine the Cobb angle from the US images, the current US image was overlaid on the previous radiograph during measurement. **Results:** Overall, 109 curves, including 62 mild ( $10\text{--}25^\circ$ ) and 47 moderate curves ( $26\text{--}45^\circ$ ) were obtained from the clinical records. However, 2 mild curves were not detected in the current US images. From the clinical records, 11 participants had curves progressed  $> 5^\circ$  between successive clinic visits, while US detected only 6. The sensitivity and specificity from US measurements were 54.5% and 96.3%, respectively. Also, the positive and negative predictive values were 75.0% and 91.2%, respectively. However, if a  $6^\circ$  difference between clinical records and the US measurement were used as the progression threshold, the sensitivity and specificity improved to 81.8% and 100%, respectively. **Conclusion:** Using a  $6^\circ$  difference between the US and previous clinical record, it was 100% specific that there was no curve progression. Therefore, US imaging can be used to monitor AIS patients without exposing them to ionizing radiation.

**1.13: Relationship between age and nonoperative utilization in elective cervical spine surgery.** *Sarfraz Malleck, Michael Johnson, Michael Goytan, Steven Passmore, Greg McIntosh.* From the University of Manitoba, Winnipeg, Man.

**Background:** Request for spine surgeon consultation often exceeds the rate at which patients can be assessed, leading to waiting periods often measured in years. Recent analysis of the Canadian Spine Outcomes and Research Network (CSORN) reported near 50% of surgically consented thoracolumbar patients received no nonoperative therapy, but those who did reported improved outcomes post-spine surgery. This raises the question: What type of treatment barriers do presurgical patients face? An understanding of this issue could lead to improved participation in presurgical functional restoration programs and potentially improved surgical outcome. Our objective was to determine whether a relationship exists between patient age and nonoperative care utilization in candidates for cervical spine surgery. Our hypothesis was that the older patients are less likely to utilize nonoperative care before cervical spine surgery. **Methods:** This was a retrospective study of prospectively collected data from 1 site within CSORN ( $n = 147$ ). Participants had degenerative spinal pathology or deformity of the cervical region, with no evidence of trauma, infection or neoplasm, and consented between January 2013 and June 2015. Data were analyzed using a 1-way analysis of variance (ANOVA) model to compare the age of elective spinal surgery patients (mean  $56.7 \pm 12.8$  yr) and their nonoperative utilization frequency ( $> 30$  times, some, none) in the 6 months before orthopedic spine surgery. **Results:** Patients who exhausted nonoperative care were significantly younger (mean  $49.7 \pm 10.4$  yr) than patients who chose not to attend nonoperative care (mean  $58.4 \pm 12.7$  yr) in the 6 months before spine

surgery ( $F_{2,146} = 3.99$ ,  $p = 0.02$ ). **Conclusion:** In this sample, older patients tended not to exhaust nonoperative care before cervical spine surgery. It is possible that older patients may no longer have the benefits, income or social supports and/or may have a different philosophy toward exercise. The extent of presurgical care is essential information for surgeons to know.

**1.14: Larger global sagittal correction associated with increased PJK and major complications, but lead to better correction and HRQoL scores.** *Alex Soroceanu<sup>\*</sup>, Justin Smith<sup>†</sup>, Virginie Lafage<sup>‡</sup>, Eric Klineberg<sup>§</sup>, Tamir Ailon<sup>¶</sup>, Christopher Ames<sup>\*\*</sup>, Christopher Shaffrey<sup>†</sup>, Munish Gupta<sup>††</sup>, Khaled Kebaish<sup>‡‡</sup>, Daniel Scubbia<sup>‡‡</sup>, Robert Hart<sup>§§</sup>, Richard Hostin<sup>¶¶</sup>, Frank Schwab<sup>‡</sup>.* From the <sup>\*</sup>University of Calgary, Calgary, Alta.; the <sup>†</sup>University of Virginia, Charlottesville, Va.; the <sup>‡</sup>Hospital for Special Surgery, New York, N.Y.; the <sup>§</sup>University of California Davis, Davis, Calif.; the <sup>¶</sup>University of British Columbia, Vancouver, B.C.; the <sup>\*\*</sup>University of California San Francisco, San Francisco, Calif.; <sup>††</sup>Washington University, St. Louis, Mo.; <sup>‡‡</sup>Johns Hopkins University, Baltimore, Ma.; <sup>§§</sup>Oregon Health & Science University, Portland, Ore.; and <sup>¶¶</sup>Baylor Scoliosis Center at Plano, Tx.

**Background:** In recent years, emphasis has been placed on restoring sagittal alignment when performing adult spinal deformity (ASD) surgery. This study examines the impact of the magnitude of sagittal correction on complications and HRQoL in ASD patients. **Methods:** Retrospective review of a multicentre database of surgical ASD patients undergoing pedicle subtraction osteotomies (PSO). Magnitude of correction was assessed using the T1-pelvic angle (TPA). Outcomes included complications, unplanned return to the operating room, postoperative alignment, and 1-year HRQoL. Multivariate linear, logistic and Poisson regression was performed. **Results:** In total, 199 patients met inclusion criteria. Larger TPA correction was associated with increased major complications (IRR 1.29 per  $10^\circ$ ,  $p = 0.004$ ), increased postoperative complications (IRR 1.28 per  $10^\circ$ ,  $p = 0.031$ ), increased proximal junctional kyphosis (PJK; OR 1.69 per  $10^\circ$ ,  $p = 0.012$ ), and more frequent unplanned return to the operating room (OR 1.86 per  $10^\circ$ ,  $p = 0.049$ ). Larger TPA correction led to better postoperative sagittal alignment (sagittal vertical axis [SVA] coefficient 19.05,  $p = 0.001$ ; PI-LL coefficient 7.81,  $p = 0.001$ , pelvic tilt coefficient 5.02,  $p = 0.0001$ ), and better improvement on the SRS-22 (coefficient 0.44,  $p = 0.0001$ ). **Conclusion:** In ASD patients with severe sagittal deformity, larger corrections led to better postoperative alignment and greater improvement in SRS-22 scores. However, this came at the cost of increased major complications, postoperative complications and increased incidence of radiographic PJK.

**1.15: Comprehensive analysis of SRS appearance domain score drivers and comparative relationship to satisfaction in adults.** *Alex Soroceanu<sup>\*</sup>, Michael Kelly<sup>†</sup>, Justin Smith<sup>‡</sup>, Justin Scheer<sup>§</sup>, Virginie Lafage<sup>¶</sup>, Themistocles Protopsaltis<sup>\*\*</sup>, Richard Lafage<sup>¶</sup>, Richard Hostin<sup>††</sup>, Khaled Kebaish<sup>‡‡</sup>, Munish Gupta<sup>‡</sup>, Robert Hart<sup>§§</sup>, Frank Schwab<sup>¶¶</sup>, Christopher Ames<sup>§</sup>.* From the <sup>\*</sup>University of Calgary, Calgary, Alta.; <sup>†</sup>Washington University, St. Louis, Mo.; <sup>‡</sup>University of Virginia, Charlottesville, Va.; <sup>§</sup>University of California San Francisco, San Francisco, Calif.; <sup>¶</sup>Hospital for Special Surgery, New York, N.Y.; <sup>\*\*</sup>New

York University, New York, N.Y.; <sup>††</sup>Baylor Scoliosis Center at Plano, Tx.; <sup>††</sup>Johns Hopkins University, Baltimore, Ma.; <sup>§§</sup>Oregon Health & Science University, Portland, Ore.

**Background:** The importance of appearance in adult spinal deformity (ASD) may be underappreciated. Little work has analyzed preoperative appearance determinants and drivers of postoperative appearance domain improvements in this population. This study aims to identify drivers of postoperative appearance scores, and assess the importance of appearance on patient satisfaction in adult spinal deformity. **Methods:** A multicentre prospective database of surgical ASD patients was reviewed. We included patients with 2-year follow up. Appearance was measured using the SRS-22 Appearance domain. We analyzed the impact of sagittal and coronal alignment on preoperative appearance scores, the impact of deformity correction on postoperative improvement of appearance scores, and the relationship between improvement on the SRS Appearance domain and patient satisfaction. Pearson correlation tests and *t* tests were performed. **Results:** In total, 260 patients met inclusion criteria. At baseline, global sagittal alignment was moderately correlated with SRS Appearance (sagittal vertical axis [SVA]  $-0.36$ ,  $p < 0.0001$ , T1 pelvic angle [TPA]  $-0.38$ ,  $p < 0.0001$ ). Baseline pelvic parameters correlated moderately with baseline SRS Appearance (pelvic tilt  $-0.31$ ,  $p < 0.0001$ , PI-LL  $-0.33$ ,  $p < 0.0001$ ). There was no correlation between baseline appearance and thoracic kyphosis or cervical alignment. There was no correlation between SRS Appearance and baseline coronal alignment. Postoperative improvement of the global sagittal alignment was associated with improvement on the SRS Appearance domain (SVA  $-0.24$ ,  $p < 0.0001$ , TPA  $0.20$ ,  $p < 0.0001$ ). There was no correlation between postoperative improvement in the coronal plane and improvement in appearance scores. Shifting the apical lordosis lower was associated with improved appearance scores. Appearance had the greatest correlation to postoperative satisfaction ( $0.51$ ,  $p < 0.0001$ ) of all SRS subdomains. **Conclusion:** Appearance score has the highest correlation to postoperative satisfaction of all domains. Those with larger sagittal malalignment at baseline had worse preoperative satisfaction scores. Greater improvement of the global sagittal alignment resulted in greater improvement of appearance scores. Coronal alignment did not impact appearance scores.

## PODIUM PRESENTATIONS

**2.16: Incremental cost to Canada's health care system of acute complications following spinal cord injury.** *Barry White\**, *Nicolas Dea†*, *John Street‡*, *Marcel Dvorak‡*. From the <sup>\*</sup>Rick Hansen Institute, Vancouver, B.C.; the <sup>†</sup>Service de neurochirurgie, l'Université de Sherbrooke, Sherbrooke, Que.; and the <sup>‡</sup>Division of Orthopaedic Spine Surgery, Department of Orthopaedics, University of British Columbia, Vancouver, B.C.

**Background:** We sought to document the hospital cost of urinary tract infections and pressure ulcers in traumatic SCI admissions at a specialized spine centre in Vancouver, B.C. **Methods:** Matched case-control methodology (direct/probabilistic) was used to estimate the excess cost of urinary tract infections (UTIs) and pressure ulcers (PUs) experienced by eligible case series participants in the Rick Hansen SCI Registry. The validated Spine Adverse Events Severity system was used to document complica-

tions. Prior to matching, participants were assigned to groups: PU group (experienced 1 or more PU); no PU group (did not experience PUs); UTI group (experienced 1 or more UTI and no other complications); and no complication group (experienced no complications). Individuals assigned to the PU group ( $n = 22$ ) were matched with individuals assigned to the no PU group ( $n = 239$ ), and individuals assigned to the UTI group ( $n = 19$ ) were matched with individuals assigned to the no complication group ( $n = 77$ ). Direct hospital costs were based on length of stay (LOS), transitions between hospital units, and unit daily costs. The excess cost of UTIs and PUs was defined as the mean difference in hospital costs between matched case series participants. **Results:** The mean difference in LOS and costs (expenditures for acute hospital accommodations, nursing services, and pharmaceuticals) in PU/no PU pairs was 15.8 days and \$18 758. The mean difference in LOS and costs in UTI/no complication pairs was 6.8 days and \$7,790. However, reviewed PUs and UTIs were largely described as complications requiring minor noninvasive treatment. **Conclusion:** The case series analysis provides conservative estimates of the hospital costs of hospital-acquired UTI and PUs in tSCI admissions to the specialized spine centre in Vancouver, B.C. Although the true extent of the personal and societal burden of hospital and community-acquired complications following tSCI is unknown, anecdotal and empirical evidence suggests significant opportunities for returns on investments in interventions and innovations aimed at preventing and treating/managing UTIs and PUs following SCI.

**2.17: The prevalence and natural history of problematic spasticity following traumatic spinal cord injury.** *Kaila A. Holtz\**, *Rachel Lipson†*, *Vanessa K. Noonan‡*, *Brian K. Kwon§¶*, *Patricia B Mills\**. From the <sup>\*</sup>Division of Physical Medicine and Rehabilitation, University of British Columbia, Vancouver, B.C.; <sup>†</sup>Emmes Canada, Burnaby, B.C.; the <sup>‡</sup>Rick Hansen Insitute, Vancouver, B.C.; <sup>§</sup>ICORD (International Collaboration on Repair Discoveries), Vancouver, B.C.; and the <sup>¶</sup>Division of Orthopaedic Spine Surgery, University of British Columbia, Vancouver, B.C.

**Background:** We sought to describe the prevalence of spasticity and antispasmodic medication use following traumatic spinal cord injury (SCI) in a large prospective cohort. **Methods:** A prospective database, the Rick Hansen SCI Registry (RHSCIR). Individuals with a traumatic SCI prospectively enrolled between 2005 and 2014 in the Vancouver site of RHSCIR were eligible for inclusion. Outcome measures included self-report measures of spasticity and abstracted antispasmodic medication use from patient charts. **Results:** In total there were 465 participants. On community discharge, the prevalence of reported spasticity was 65%. The prevalence of problematic spasticity (defined as being on an antispasmodic medication) was 35%. Both values remained stable in community follow-up at 1, 2 and 5 years postinjury. Being discharged on antispasmodic medications was significantly associated with patients reporting ongoing spasticity treatment in community follow-up. Relative to all others, patients with cervical and thoracic motor incomplete (AIS C) injuries had the highest prevalence of ongoing problematic spasticity. **Conclusion:** Spasticity is a significant medical consequence of SCI. It can be problematic even 5 years postinjury, particularly in patients with incomplete cervical and thoracic injuries. Ongoing



spasticity treatment in the community is required in one-third of patients with traumatic SCI. Future research is needed to determine optimal clinical management strategies to identify and treat individuals with the highest risk of problematic spasticity.

**2.18: Exploring the possibility of using artificial neural networks to predict mortality after spinal cord injury.** *Nader Fallab<sup>††</sup>, Vanessa Noonan<sup>††</sup>, Jeffery Shum<sup>\*</sup>, Carly Rivers<sup>\*</sup>, John Street<sup>‡</sup>, So Eyun Park<sup>\*</sup>, Elaine Chan<sup>\*</sup>, Tova Plasbkes<sup>\*</sup>, Marcek Dvorak<sup>‡</sup>.* From the <sup>\*</sup>Rick Hansen Institute, Vancouver, B.C.; the <sup>††</sup>University of British Columbia, Vancouver, B.C.; and the <sup>‡</sup>Division of Orthopaedic Spine Surgery, Department of Orthopaedics, University of British Columbia, Vancouver, B.C.

**Background:** The objective of this study was to determine whether abbreviated injury scale (AIS) score data in individuals with traumatic SCI (tSCI) exhibited nonlinearity, to propose a new methodology to compute the AIS score that accounts for nonlinearity and compare with the conventional ISS, which also utilizes AIS data, in its ability to predict in-patient mortality. **Methods:** We used demographic and clinical data from persons with tSCI, excluding those with complete injuries, treated at an acute spine centre from 2004 to 2012. Linear principal component analysis (PCA), nonlinear PCA (NLPCA) and neural networks (NN) were used to compute the AIS score. The NLPCA was based on a feed-forward back-propagation NN with 5 layers: input, 3 hidden, and output. Multivariable logistic regression models were used to assess mortality prediction. **Results:** The study cohort consisted of 500 persons with tSCI: 79% male, mean age 49.3 ± 19.2, and 13.2% in-patient mortality incidence. We identified that due to the nonlinearity of AIS score data, NLPCA outperformed ISS and linear PCA in predicting in-patient mortality. The regression coefficients were: 0.44, 0.48 and 0.56 for ISS, linear and nonlinear PCA, respectively ( $p < 0.01$ ). Additional NNs were used to explore interactions among all risk factors and AISS-NLPCA. These confirmed that age, completeness and neurologic level of injury, AIS score-NLPCA and classification of spinal column fracture exhibit nonlinearity, influence mortality prediction, and need to be considered in the development of future prediction models. **Conclusion:** Use of NN methodology to compute the AIS score improved the accuracy of predicting acute in-patient mortality following tSCI by accounting for nonlinearity. Results of this study will inform the development of new prediction models for mortality after SCI that can inform clinical decision-making and be used in SCI research. This approach may also be suitable for other clinical measures where the data exhibits nonlinearity.

**2.19: Developing a new index to predict mortality after spinal cord injury using machine learning techniques.** *Vanessa Noonan<sup>††</sup>, Nader Fallab<sup>††</sup>, Manekta Bedi<sup>\*</sup>, Elaine Chan<sup>\*</sup>, Carly Rivers<sup>\*</sup>, John Street<sup>‡</sup>, Tova Plasbkes<sup>\*</sup>, Marcek Dvorak<sup>‡</sup>.* From the <sup>\*</sup>Rick Hansen Institute, Vancouver, B.C.; the <sup>††</sup>University of British Columbia, Vancouver, B.C.; and the <sup>‡</sup>Division of Orthopaedic Spine Surgery, Department of Orthopaedics, University of British Columbia, Vancouver, B.C.

**Background:** The objective of this study was to develop an index (the Spinal Cord Injury Risk Score [SCIRS]) to determine the risk of in-hospital mortality in persons who arrive at an SCI Centre with a traumatic SCI (tSCI). **Methods:** Data from persons

with a tSCI enrolled in the Vancouver Rick Hansen SCI Registry from 2004 to 2012 were included in the development of SCIRS. Using machine learning techniques, nonlinear combination of demographic, clinical and associated injury (measured by the abbreviated injury scale [AIS]) factors was evaluated. Potential factors were identified from bivariate analysis and had statistically significant nonlinear relations to mortality prediction. Continuous variables were divided into ranges based on logistic regression, neural network and decision tree models. Weights were assigned to each range and to categorical variables according to their ability to predict mortality. Validation involved comparing accuracy of acute mortality prediction of the SCIRS with the ISS and the Trauma and Injury Severity Score (TRISS) using area under the receiver operating characteristics curve (AUROC). **Results:** The cohort consisted of 849 persons: 82% male, mean age 46.3 ± 19.8, 39% complete injuries, and 17% incidence of in-hospital mortality. Variables included in the SCIRS, which is scored out of 25, were age, neurologic level and completeness of injury, classification of spinal column fracture and the AIS (excluding spine). The values for AUROC, where higher values show greater overall accuracy and performance of each index, were 0.820 (SCIRS), 0.600 (ISS) and 0.699 (TRISS). Additionally, the correctly predicted percentages based on a concordance matrix from logistic regression were 85.4%, 20.4% and 76.2%, respectively. **Conclusion:** Use of a new instrument (SCIRS) improved accuracy in predicting acute in-patient mortality after tSCI compared with conventional injury severity scores. SCIRS will help clinicians in early decision-making for SCI patients. However, further validation is needed.

**2.20: The impact of complications and opportunities to improve function, health and quality of life: our best approach to “cure” SCI today.** *Joel Finkelstein<sup>\*</sup>, Vanessa Noonan<sup>††</sup>, Nader Fallab<sup>††</sup>, Chester Ho<sup>§</sup>, Eve Tsai<sup>¶</sup>, Carly Rivers<sup>†</sup>, Catherine Truchon<sup>\*\*</sup>, A. Gary Linassi<sup>††</sup>, Colleen O’Connell<sup>††</sup>, Andrea Townson<sup>‡</sup>, Henry Abn<sup>§§</sup>, Brian Drew<sup>¶¶</sup>, Marcel Dvorak<sup>‡</sup>, Michael G. Fehlings<sup>§§\*\*\*</sup>, Carolyn Schwartz<sup>†††</sup>, Luc Noreau<sup>†††</sup>.* From the <sup>\*</sup>Sunnybrook Health Sciences Centre, Toronto, Ont.; the <sup>†</sup>Rick Hansen Institute, Vancouver, B.C.; the <sup>††</sup>University of British Columbia, Vancouver, B.C.; the <sup>§</sup>University of Calgary, Calgary, Alta.; the <sup>¶</sup>University of Ottawa, Ottawa, Ont.; the <sup>\*\*</sup>Institut national d’excellence en santé et en services sociaux (INESSS), Québec, Que.; the <sup>††</sup>University of Saskatchewan, Saskatoon, Sask.; <sup>‡</sup>Dalhousie Medicine New Brunswick, Fredericton, N.B.; <sup>§§</sup>University of Toronto, Toronto, Ont.; <sup>¶¶</sup>McMaster University, Hamilton, Ont.; <sup>\*\*\*</sup>Toronto Western Hospital, Toronto, Ont.; <sup>†††</sup>Delta-Quest Foundation Inc., Concord, Mass., and <sup>†††</sup>Université Laval, Center for Interdisciplinary Research in Rehabilitation and Social Integration, Quebec City, Que.

**Background:** Our objective was to analyze associations among injury and demographic variables, health status, and life satisfaction in persons with traumatic spinal cord injury (tSCI). **Methods:** Patients admitted with tSCI enrolled in the Rick Hansen SCI Registry (RHSCIR) from 2004 to 2014 were included. A 5-layer path analysis was used to examine associations among Layer 1–tSCI severity (ASIA Impairment Score [AIS], AIS A [complete] to AIS D [incomplete]) and anatomic level (cervical, thoracolumbar), age, marital status, education, living situation/setting; Layer

2—number of complications at follow-up; Layer 3—1 year postdischarge Functional Independence Measure (FIM); Layer 4—physical (PCS) and mental (MCS) component scores of the SF-36 version 2; and Layer 5—Life Satisfaction-11 score. Path analysis was conducted using Mplus 7.1. Model fit was assessed using  $\chi^2$ , comparative fit index, root mean square error, and standardized root mean square residual. **Results:** In total, 599 participants were included: 79.5% were male, mean age was  $44.8 \pm 18.2$  years, and 33.2% were motor/sensory complete (AIS A). Model fit was excellent. Complications increased with age, more severe injuries, higher BMI, unemployment, and assisted living. FIM decreased (lower function) with more severe injuries, unemployment, living alone, and with having multiple complications. PCS and MCS decreased (worse physical/mental health) with lower education, and more complications. PCS was lower in participants with more severe injuries, but MCS was not. A higher MCS was associated with a lower FIM (surrogate of injury severity) and higher LISAT score (greater life satisfaction) was associated with being married, higher FIM, and fewer complications. **Conclusion:** Older age, unemployment, living setting and more severe injuries are associated with greater complications and poorer function. Participants with severe injuries adapt better, which is likely due to participants with incomplete injuries having higher expectations for recovery. Complications negatively impact function, health (mental/physical) and life satisfaction and provide an opportunity for clinicians to significantly improve patient outcome.

**2.21: Delays in time from injury to specialized SCI centres increase in-hospital mortality in acute SCI.** *Carly Rivers\**, *Freda Warner†*, *Vanessa Noonan†*, *Nader Fallab†*, *Charles Fisher†*, *Colleen O'Connell‡*, *Eve Tsai§*, *Henry Ahn¶*, *Najmedden Attabib\*\**, *Sean Christie\*\**, *Brian Drew††*, *Joel Finkelstein††*, *Daryl Fourney§§*, *Jérôme Paquet¶¶*, *Stefan Parent\*\*\**, *Diliner Kuerban\**, *Marcel Dvorak¶¶*. From the \*Rick Hansen Institute, Vancouver, B.C.; the †University of British Columbia, Vancouver, B.C.; the ‡Stan Cassidy Centre for Rehabilitation, Fredericton, N.B.; the §University of Ottawa, Ottawa, Ont.; the ¶University of Toronto, Toronto, Ont.; \*\*Dalhousie University, Halifax, N.S.; ††McMaster University, Hamilton, Ont.; the ‡‡Sunnybrook Health Sciences Centre, Toronto, Ont.; the §§University of Saskatchewan, Saskatoon, Sask.; ¶¶Laval University, Québec, Que.; and \*\*\*Université de Montréal, Montréal, Que.

**Background:** Despite improvements in prevention and care, the life expectancy of those with traumatic spinal cord injury (tSCI) remains lower than for able-bodied individuals. The objectives of this study are to determine the incidence of in-hospital mortality and the importance of patient-, injury- and system-level risk factors on in-hospital mortality. **Methods:** In-hospital mortality was defined as death that occurred during an in-hospital admission at a specialized SCI centre following tSCI. In total 3446 tSCI patients in the Rick Hansen SCI Registry were identified (2004–2014). Kaplan–Meier curves and Cox regression were used to examine the effect (unadjusted and adjusted) of age, sex, etiology, level of injury (C1–T9), ASIA Impairment Scale (AIS) grade (A–D), injury severity score (ISS), Charlson Comorbidity Index (CCI), and time to acute care admission at a Rick Hansen SCI Registry (RHSCIR) site in identifying risk of in-hospital mortality. **Results:** The overall incidence of in-hospital mortality was

6% (207 of 3446); 1499 had all model data available, of whom 79 (5.3%) died in-hospital. Significant predictors of mortality identified in the multivariable model included increasing age (HR 3.24 for 61–75 yr, HR 19.07 for 76+ yr), CCI  $\geq 3$  (HR 4.31), cervical injuries (low cervical HR 3.14, high cervical HR 6.36), AIS A injuries (HR 3.46) and time to acute care  $> 12$  h (HR 1.73). Available ICD-10 codes identified head trauma in 7.2% of nonmortality cases and 17.6% of mortality cases. **Conclusion:** As expected, in-hospital mortality is influenced by multiple factors, including age and injury level/completeness, and comorbidities can be used to identify high-risk patients. Delays in transport to specialized SCI centres was an important, unexpected factor associated with increased mortality (73% increased risk in those transported  $> 12$  h), which supports previous evidence supporting the need for specialized care for these patients.

**2.22: The modified extremity motor (MEM) classification: A neurological classification of traumatic central cord syndrome (TCCS).** *Jin Tee\**, *Jérôme Paquet†*, *Vanessa Noonan\*\**, *Brian Kwon\**, *Eve Tsai§*, *Sean Christie¶*, *Carly Rivers‡*, *Diliner Kuerban‡*, *Henry Ahn\*\**, *Najmedden Attabib¶*, *Christopher Bailey††*, *Brian Drew††*, *Michael Feblings\*\**, *Joel Finkelstein\*\**, *Daryl Fourney§§*, *R. John Hurlbert¶¶*, *Stefan Parent\*\*\**, *Charles Fisher\**, *Marcel Dvorak\**. From the \*University of British Columbia, Vancouver, B.C.; †Laval University, Québec, Que.; the ‡Rick Hansen Institute, Vancouver, B.C.; the §University of Ottawa, Ottawa, Ont.; ¶Dalhousie University, Halifax, N.S.; the \*\*University of Toronto, Toronto, Ont.; ††Western University, London, Ont.; ‡‡McMaster University, Hamilton, Ont.; the §§University of Saskatchewan, Saskatoon, Sask.; the ¶¶University of Calgary, Calgary, Alta.; and \*\*\*Université de Montréal, Montreal, Que.

**Background:** We sought to introduce a neurologic classification of TCCS based on the difference of upper- and lower-extremity motor scores (UEMS < LEMS). **Methods:** The Rick Hansen SCI Registry (RHSCIR) was queried for cervical spine trauma patients with baseline ASIA Impairment Scale (AIS) grades of C/D from registry conception to September 2015. Neurological standards were as defined by the International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI). Two neurologic classifications were devised and examined: (1) MEM with UEMS < LEMS of 1–10 and  $> 10$ ; and (2) alternative with UEMS < LEMS of 1–4, 5–10,  $> 10$ . Statistical methods included bivariate and multivariate regression modelling. **Results:** The RHSCIR query returned 240 patients with AIS C/D and UEMS < LEMS of  $\geq 1$ . Both groups had similar demographics. The MEM classification was able to discriminate for neurologic outcome on discharge ( $p = 0.0197$ ). The MEM classification was also able to discriminate for (1) ratio of high to low cervical (C1–C4) injuries ( $p = 0.0121$ ); (2) mean admission UEMS ( $p < 0.0001$ ); (3) total motor score on admission ( $p < 0.0001$ ). The alternative TCCS classification group was not able to discriminate for outcome ( $p = 0.0613$ ). It was, however, able to discriminate for (1) mechanism of injury ( $p = 0.0224$ ); (2) ratio of high cervical (C1–C4) to low cervical (C5–C7) injury levels ( $p = 0.0258$ ); (3) mean admission UEMS ( $p < 0.0001$ ). **Conclusion:** The MEM classification, an AIS motor score based neurologic classification of TCCS, discriminates for neurologic outcome and, as such, can be used for both research and clinical purposes.

**2.23: The stable spine central cord syndrome (SCCS): a prospective surgical cohort.** *Jérôme Paquet\**, *Vanessa Noonan<sup>‡</sup>*, *Brian Kwon<sup>†</sup>*, *Eve Tsai<sup>§</sup>*, *Sean Christie<sup>¶</sup>*, *Carly Rivers<sup>‡</sup>*, *Henry Abn<sup>\*\*</sup>*, *Najmedden Attabib<sup>¶</sup>*, *Christopher Bailey<sup>††</sup>*, *Brian Drew<sup>‡‡</sup>*, *Michael Feblings<sup>\*\*</sup>*, *Joel Finkelstein<sup>\*\*</sup>*, *Daryl Fourney<sup>§§</sup>*, *R. John Hurlbert<sup>¶¶</sup>*, *Stefan Parent<sup>\*\*\*</sup>*, *Diliner Kuerban<sup>†</sup>*, *Marcel Dvorak<sup>†</sup>*. From <sup>\*</sup>Laval University, Québec, Que.; the <sup>†</sup>University of British Columbia, Vancouver, B.C.; the <sup>‡</sup>Rick Hansen Institute, Vancouver, B.C.; the <sup>§</sup>University of Ottawa, Ottawa, Ont.; <sup>¶</sup>Dalhousie University, Halifax, N.S.; the <sup>\*\*</sup>University of Toronto, Toronto, Ont.; <sup>††</sup>Western University, London, Ont.; <sup>‡‡</sup>McMaster University, Hamilton, Ont.; the <sup>§§</sup>University of Saskatchewan, Saskatoon, Sask.; the <sup>¶¶</sup>University of Calgary, Calgary, Alta.; and <sup>\*\*\*</sup>Université de Montréal, Montreal, Que.

**Background:** Traumatic central cord syndrome (TCCS) is a clinical diagnosis. Emergent surgical treatment is usually the gold standard for tSCI. However, optimal treatment sequence for the central cord injury population with “isolated” spondylotic or “stable spine” (stable spine central cord syndrome [SCCS]) is uncertain. Literature specifically addressing this topic is sparse and of poor quality. Similarly, few articles have clearly separated TCCS using spine stability as a variable for their analysis. The purpose of this study was to determine any demographic, surgical practice or outcome differences in the treatment of TCCS patients, using spine stability as the main variable, from a prospective tSCI database. **Methods:** The tSCI patients from the Rick Hansen SCI Registry (RHSCIR), prospectively recruited from 2004 to 2014 from 18 acute care participating centres across Canada, were studied. Those with ASIA Impairment Scale (AIS) A–D and cervical level of injury (C0–T1) were divided into the SCCS cohort (stable) and the unstable cervical spine (UCS) cohort. Patient, surgical, and systems data and outcome (change in motor score) were compared using  $\chi^2$  or Wilcoxon tests as appropriate. **Results:** In total, 533 participants were included, 176 (11.8%) with SCCS. Compared with the UCS cohort, SCCS patients were older (58.8 v. 44.1 yr), more likely male (86.4 v. 75.9%), injured by a fall (67.4% v. 35.1%), having comorbidities (41.6% v. 18.9%), and having AIS C/D (81.3% v. 47.3%) and high cervical injuries (58.5% v. 43.1%). SCCS patients were less likely to have surgery (67.6% v. 92.7%), and when having surgery had a longer delay from injury to surgery (77.2 v. 49.1 h). The SCCS cohort had a significantly greater change in total motor score from admission to discharge (23.2 v. 17.0 points) compared with the UCS cohort. **Conclusion:** The SCCS population seems to be uniquely related to demographics, neurology, management and outcomes. Inclusion of spine stability with neurology variables is a more accurate way to classify CCS.

**2.24: Changes following acute traumatic spinal cord injury: a prospective pilot study on serial MRIs.** *Joost Rutjes*, *Brian Kwon*, *Marcel Dvorak*. From the Vancouver General Hospital, Vancouver, B.C.

**Background:** The extent of spinal cord compression, hemorrhage and edema on MRI scans of patients with acute SCI have been reported to be potential predictors of neurologic recovery. However, little is known regarding the temporal changes of these MRI findings in the first weeks after injury. Therefore the objective of this study is to characterize the dynamic nature of these

MRI findings during the first weeks following SCI. Our goal is to understand how these MRI changes relate to both early and late neurologic function. **Methods:** Patients with acute traumatic cervical SCI admitted within 24 h after injury were eligible. Six serial scans were planned at 24 h, 48 h, 96 h, and at 1, 2 and 3 weeks after injury. On each scan, vertical length of cord edema, anatomic point of cord compression, maximum spinal cord compression, maximum canal compromise, presence and length of hematoma were determined. **Results:** Eight patients (mean age 54 yr) with acute traumatic SCI were included. Injury level ranged from C4 to C6 and the baseline ASIA Impairment Scale (AIS) grade ranged from A to D. Compared with the initial MRI, the length of cord edema increased in the first 96 h with 40% followed by a gradual decrease, resulting in 20% less edema at 3 weeks. Hematoma was found only in the AIS-A patients. Length of hematoma was stable during the first 2 weeks and decreased to 60% at 3 weeks after injury. Spinal cord compression and bony spinal canal compromise were 24% and 34%, respectively, on the initial MRI, and were both resolved at 3 weeks. **Conclusion:** Although preliminary, this study identified a clear pattern of spinal cord changes in the first weeks after injury on MRI. The vertical length of edema peaks around 96 h, and then begins to subside. Many of the acute changes have resolved by 3 weeks postinjury.

**2.25: Next-generation MRI identifies tract-specific injury and predicts focal neurological deficits in degenerative cervical myelopathy: development and characterization of accurate imaging biomarkers for spinal cord pathologies.** *Allan R. Martin\**, *Izabela Aleksanderek\**, *Julien Cohen-Adad<sup>†</sup>*, *David W. Cadotte\**, *Sukhvinder Kalsi-Ryan\**, *Benjamin De Leener<sup>‡</sup>*, *Justin Wang<sup>‡</sup>*, *Adrian Crawley\**, *David J. Mikulis\**, *Howard Ginsberg\**, *Michael G. Feblings\**. From the <sup>\*</sup>University of Toronto, Toronto, Ont.; <sup>†</sup>École Polytechnique de Montréal, Montreal, Que.; and <sup>‡</sup>Queen's University, Kingston, Ont.

**Background:** MRI techniques are emerging that can characterize aspects of spinal cord microstructure: diffusion tensor imaging (DTI), magnetization transfer (MT), and  $T_2^*$ -weighted imaging. This prospective study investigated if these techniques can quantify injury to individual tracts and predict focal neurologic impairments in degenerative cervical myelopathy (DCM). **Methods:** Twenty-eight DCM patients (mean age 55.3, 68% male, 15 mild, 7 moderate, 6 severe) underwent detailed clinical assessments and multimodal MRI (3 T GE), and 23 healthy individuals served as controls, undergoing MRI. Analysis with Spinal Cord Toolbox extracted fractional anisotropy (FA), mean diffusivity (MD), magnetization transfer ratio (MTR), and  $T_2^*$  white matter (WM):grey matter (GM) ratio (reflecting grey–white contrast) from lateral corticospinal tracts (LCSTs), dorsal columns (DCs) and spinothalamic tracts (STTs) at C1–C2. Spearman's rank correlations were calculated between each metric in each WM tract and the following measures of focal neurologic/functional impairment in DCM participants: mJOA upper/lower extremity (UE/LE) motor scores, UE strength, Jamar grip force, UE sensation and Berg Balance Scale (BBS). **Results:** DCM participants showed reduced FA ( $p < 0.05$ ), increased MD ( $p = 0.07$ ), decreased MTR ( $p < 0.05$ ) and increased  $T_2^*$ -WM:GM ratio ( $p < 0.05$ ) compared with healthy controls. Among MRI metrics, FA provided the strongest correlations with all clinical measures (all  $p < 0.05$ ). The strongest correlation with mJOA

motor scores was FA of the bilateral LCSTs ( $r = 0.64$ ). FA of the ipsilateral LCST predicted arm power (left:  $r = 0.62$ , right:  $r = 0.57$ ) and grip strength (left:  $r = 0.56$ , right:  $r = 0.54$ ). FA of the DCs correlated well with ipsilateral sensation (left:  $r = 0.66$ , right:  $r = 0.67$ ,  $p < 0.05$ ) but the contralateral STTs did not (left:  $r = 0.31$ , right:  $r = 0.27$ ,  $p = 0.14$ ). FA in the DCs correlated moderately with BBS ( $r = 0.51$ ). **Conclusion:** Advanced MRI techniques demonstrate pathological WM changes rostral to cord compression in DCM. In particular, the DTI metric FA can quantify tract-specific injury and predict focal deficits. This lays the groundwork for the establishment of accurate imaging biomarkers for spinal cord pathologies.

**2.26: Translating state-of-the-art spinal cord MRI techniques to clinical use: a systematic review of clinical studies using DTI, MT, MWF, MRS and fMRI.** *Allan R. Martin\**, *Izabela Aleksanderek\**, *Julien Cohen-Adad†*, *Zenovia Tarmobamed‡*, *Lindsay Tetreault\**, *Nathaniel Smith§*, *David W. Cadotte\**, *Adrian Crowley\**, *Howard Ginsberg\**, *David J. Mikulis\**, *Michael G. Feblings\**. From the \*University of Toronto, Toronto, Ont.; †École Polytechnique de Montréal, Montreal, Que.; ‡Royal College of Surgeons in Ireland, Dublin, Ireland; and §McMaster University, Hamilton, Ont.

**Background:** A recent meeting of international imaging experts sponsored by the International Spinal Research Trust (ISRT) and the Wings for Life foundation identified 5 state-of-the-art MRI techniques with potential to transform the field of spinal cord imaging by elucidating aspects of microstructure and function: diffusion tensor imaging (DTI), magnetization transfer (MT), myelin water fraction (MWF), magnetic resonance spectroscopy (MRS) and functional MRI (fMRI). **Methods:** A systematic review was conducted using MEDLINE, EMBASE and Cochrane databases to identify English-language studies that investigated utility, in terms of diagnosis, correlation with disability and prediction of outcomes, of these techniques in spinal cord pathologies. Data regarding study design, participants, technical methods, clinical measures and analysis techniques were extracted to identify trends. Studies were assessed for risk of bias, and overall quality of evidence was assessed using GRADE. **Results:** Our search returned 6597 unique citations, and after full-text review of 274 articles, 104 were included. Sixty-nine DTI and 25 MT studies were identified, with both recently showing sharp increases, in addition to 1 MWF, 11 MRS and 8 fMRI studies. Most studies were exploratory, showing high (73%) or moderately high (21%) risk of bias. Acquisition techniques varied widely across studies. The DTI metric fractional anisotropy (FA) showed moderate evidence of correlating with disability in several pathologies, low evidence of group differences versus controls, and insufficient evidence for diagnosis or prognosis. Numerous other metrics show very low evidence to demonstrate group differences, and insufficient evidence as diagnostic tests, biomarkers, or prognostic tools. **Conclusion:** Novel MRI techniques have tremendous potential to enhance management of spinal pathologies, but current evidence shows limited clinical utility. DTI is the most mature, but requires further refinement and standardization before widespread utilization. Studies with a priori hypotheses, standardized acquisitions, detailed clinical assessments and automated analysis tools are needed to facilitate clinical translation.

**2.27: Motor cortex electrical stimulation to promote spinal cord injury recovery in an animal model.** *Andrew Jack*, *Andrew Nataraj*, *Karim Fouad*. From the University of Alberta, Edmonton, Alta.

**Background:** Many treatment regimens for SCI have been trialed with limited success. Electrical stimulation (ES) to promote corticospinal tract (CST) repair has been more recently examined, though remains underinvestigated. We examine the role of motor cortex ES on axonal regrowth, plasticity and functional recovery in an SCI rat model. **Methods:** A dorsal lateral quadrant SCI was performed at C4 in 50 rats. Animal groups consisted of ES333 rats (333 Hz, biphasic pulse, 0.2 ms duration every 500 ms), ES20 (20 Hz, biphasic pulse, 0.2 ms duration every 1 ms), SCI only rats, and sham rats (insertion of electrodes without stimulation). Rats were trained in the Montoya grasping stairwell task with subsequent SCI and ES. Postinjury reaching scores were recorded weekly, and histological and lesion analysis completed quantifying axonal regrowth (both collateralization and regeneration). **Results:** Each respective animal group's post-lesioning grasping success ( $p < 0.001$ , analysis of variance [ANOVA]) and farthest well reached was significantly lower than baseline values ( $p < 0.001$ , ANOVA). No significant difference was found between groups for CST lesion size, nor postinjury reaching success ( $p = 0.48$ , ANOVA). However, an inadequate sample size cannot be ruled out in explaining the lack of effect seen from ES on clinically relevant functional outcomes (post hoc power analysis 0.59). Significantly more collaterals (axonal sprouts rostral to lesion) were found in the ES animals compared with control animals (ES333  $p < 0.001$  and ES20  $p = 0.02$ , ANOVA), although no difference was found between the 2 ES groups ( $p = 0.86$ , ANOVA). Furthermore, no difference was found with respect to the degree of axonal regeneration into the lesion between groups ( $p = 0.51$ , ANOVA). **Conclusion:** A greater extent of outgrowth (collateralization) was found in ES-treated rats suggesting increased axonal plasticity, though functional outcomes were no different. ES is a promising SCI therapy; however, further investigation is required before translation to human models can take place.

**2.28: Role of muscle damage on loading at the level adjacent to a lumbar spine fusion: a biomechanical analysis.** *Masoud Malakoutian\**, *John Street†*, *Hans-Joachim Wilke‡*, *Ian Stavness§*, *Marcel Dvorak†*, *Sidney Fels¶*, *Thomas Oxlund\*\**. From the \*Department of Mechanical Engineering, University of British Columbia, Vancouver, B.C.; †Department of Orthopaedics, University of British Columbia, Vancouver, B.C.; ‡Centre of Musculoskeletal Research, Ulm University, Ulm, Germany; §Department of Computer Science, University of Saskatchewan, Saskatoon, Sask.; and ¶Department of Electrical and Computer Engineering, University of British Columbia, Vancouver, B.C.

**Background:** It is well-established that posterior spinal surgery results in damage to the paraspinal musculature. The effects of such iatrogenic changes on spinal loading have not been previously investigated, particularly at levels adjacent to a spinal fusion. Therefore, the objective of this study was to investigate the effect of simulated muscle damage on postoperative spinal loading at the adjacent levels to a spinal fusion during upright

postures using a mathematical model. **Methods:** A musculoskeletal model of the spine using ArtiSynth with 210 muscle fascicles was used to predict spinal loading in an upright posture. The loading at L1–L2 and L5–S1 were estimated before and after simulated paraspinal muscle damage (i.e., removal of muscle attachments at L2–L5) along the lumbar spine, both with a spinal fusion at L2–L5 and without a spinal fusion. **Results:** The axial compressive forces at the adjacent levels increased after simulated muscle damage, with the largest changes being at the rostral level (78% increase in presence of spinal fusion; 73% increase without spinal fusion) compared with the caudal level (41% in presence of fusion; 32% without fusion). Shear forces increased in a similar manner at both the rostral and caudal levels. These changes in loading were due to a redistribution of muscle activity from the local lumbar to the global spinal musculature. **Conclusion:** The results suggest that the paraspinal muscles of the lumbar spine play an important role in adjacent segment loading of a spinal fusion, independent of the presence of rigid spinal instrumentation.

**2.29: Classifying injury severity and predicting neurologic outcome after acute human spinal cord injury with cerebrospinal fluid biomarkers.** *Brian Kwon\**, *Femke Streijger\**, *Nader Fallab†*, *Vanessa Noonan†*, *Scott Paquette\**, *Michael Boyd\**, *Tamir Ailon\**, *John Street\**, *Charles Fisher\**, *Marcel Dvorak\**. From the \*University of British Columbia, Vancouver, B.C.; and the †Rick Hansen Institute, Vancouver, B.C.

**Background:** Neurologic impairment after SCI is currently measured and classified by functional examination (i.e., the ASIA impairment scale [AIS] and ISNCSCI exam). These are gross measures of spinal cord pathology and imprecise predictors of neurologic outcome. The objective of this study was to determine how well inflammatory and structural proteins within the cerebrospinal fluid (CSF) of acute SCI patients predicted their AIS grade conversion and motor score improvement. **Methods:** Fifty individuals with acute SCI (29 AIS A, 9 AIS B, 12 AIS C) were prospectively enrolled at our level 1 trauma centre (32 cervical, 18 thoracic). Lumbar intrathecal catheters were inserted at the time of surgery to obtain CSF samples over 3–5 days. A bead multiplex array and enzyme-linked immunosorbent assay (ELISA) were performed for inflammatory cytokines and structural proteins: IL-6, IL-8, MCP-1, IL-16, IP-10, IL-16, TNF-R1, Tau, S100 $\beta$ , and GFAP. The 24-h postinjury CSF concentrations were analyzed in relation to baseline AIS grade, AIS grade improvement (“conversion”) over 6 months, and motor score improvement over 6 months. **Results:** The 24-h postinjury CSF levels of IL-6, tau, S100 $\beta$ , and GFAP were each strongly correlated with baseline AIS grade of A, B, or C. For both cervical and thoracic SCI, the IL-6, IL-8, MCP1, Tau, S100 $\beta$ , and GFAP concentrations strongly predicted AIS conversion at 6 months postinjury. Using locally weighted linear regression (Lowess) modelling, the combination of IL-6 and S100 $\beta$  clearly identifies cervical and thoracic SCI patients who will not spontaneously recover motor function. **Conclusion:** The analysis of CSF can provide valuable biological information about injury severity after acute SCI. Such biological markers may be valuable tools for stratifying individuals in acute clinical trials where variability in spontaneous recovery requires large recruitment cohorts for sufficient power.

**2.30: Spine surgery a mari usque ad mare.** *Godefroy Hardy St-Pierre*, *John Hurlbert*. From the University of Calgary, Calgary, Alta.

**Background:** CSORN is the spine registry of the Canadian Spine Society. For the first time, we use this powerful tool to directly compare outcomes of thoracolumbar procedures among 5 surgical centres across the country: Vancouver, BC; Calgary Alta.; Edmonton, Alta.; Toronto, Ont.; and Saint John, NB. **Methods:** We extracted data from the main CSORN database concerning outcome metrics preoperatively and at 6 months postoperative. Those metrics were visual analogue scale (VAS) back pain, VAS leg pain, SF-12 physical component, SF-12 mental component, EuroQol5D index, Health scale, PHQ9 and ODI. Five additional metrics were retrieved, namely operating room (OR) time, estimated blood loss, dural tear, perioperative adverse event and first follow-up adverse event. Average difference in VAS LE, EQ5D index and ODI were computed. Analysis of variance (ANOVA) was used as a preliminary analysis. **Results:** There was a total of 1534 patients across the 5 centres. Calgary and Edmonton were agglomerated under Alberta for analysis. Average preoperative VAS back pain was 7.08, 6.13, 6.77, 6.63, respectively, and VAS leg pain was 7.30, 7.17, 7.54, 7.58, respectively for Saint John, Toronto, Alberta and Vancouver. Average EQ5D index was 0.57, 0.54, 0.42, 0.67, respectively and average preoperative ODI was 48.05, 43.09, 50.70, 47.30, respectively. Average improvement in VAS LE at 6 months was 3.59, 4.63, 3.99, 5.61, respectively; improvement for EQ5D was 0.12, 0.18, 0.41, 0.01, respectively; and improvement for ODI was 14.22, 14.09, 26.46, 23.14, respectively. Average OR time (min) was 123.38, 166.52, 155.22, 253.84, respectively. Average blood loss (mL) was 379.44, 337.46, 291.33, 653.17, respectively. Rate of dural tear was 5%, 12%, 3%, 13%, respectively; perioperative AE was 30%, 4.8%, 13%, 40%, respectively; and FUP AE 16%, 0%, 3%, 25% respectively. ANOVA showed no difference between preoperative VAS back, LE or EQ5D ( $p = 0.124, 0.525, 0.07$ , respectively), but a difference in preoperative ODI ( $p = 0.048$ ), and improvement at 6 months in VAS LE, EQ5D and ODI ( $p < 0.005$  for all 3). **Conclusion:** Further statistical analysis is necessary to properly characterize the difference in outcome between the surgical centres, notably subgroup analyses and stratification per procedure performed. Preliminary analysis suggests there are statistically significant differences between centres.

## PODIUM PRESENTATIONS

**3.31: Prognostic factors for survival in a surgical series of symptomatic metastatic epidural spinal cord compression: a prospective North American multi-centre study in 142 patients.** *Anick Nater\**, *Michael Feblings\**, *Lindsay Tetreault\**, *Branko Kopjar†*, *Paul Arnold‡*, *Mark Dekutoski§*, *Joel Finkelstein¶*, *Charles Fisher\*\**, *John France††*, *Ziya Gokaslan‡‡*, *Eric Massicotte\**, *Laurence Rhines§§*, *Peter Rose¶¶*, *Arjun Sabgal¶¶*, *James Schuster\*\*\**, *Alexander Vaccaro†††*. From the \*University of Toronto, Toronto, Ont.; the †University of Washington, Seattle, Wash.; the ‡University of Kansas Medical Center, Kansas City, Kansas; the §CORE Institute, Phoenix, Ariz.; the ¶Sunnybrook Health Sciences Centre, Toronto, Ont.; the \*\*University of British Columbia and

Vancouver Coastal Health, Vancouver, B.C.; <sup>††</sup>West Virginia University, Morgantown, W. Va.; the <sup>††</sup>Rhode Island Hospital, Providence, R.I.; the <sup>§§</sup>University of Texas MD Anderson Cancer Center, Houston, Texas; the <sup>¶¶</sup>Mayo Clinic, Rochester, Minn.; the <sup>\*\*\*</sup>University of Pennsylvania, Philadelphia, Pa.; and <sup>†††</sup>Thomas Jefferson University, Philadelphia, Pa.

**Background:** Symptomatic metastatic epidural spinal cord compression (MESCC) afflicts up to 10% of all cancer patients and is associated with shortened survival and worsened quality of life. This study aims to identify the key survival prognostic factors in MESCC patients who were surgically treated for a single symptomatic lesion. **Methods:** In total, 142 MESCC patients were enrolled in a prospective North American multicentre study and followed postoperatively for 12 months. Using univariate analyses, Kaplan–Meier methods and log-rank tests the prognostic value of various clinical predictors were assessed. Noncollinear predictors with  $p < 0.05$  in univariate analyses were included in the final Cox proportional hazards model. **Results:** The overall median survival was 7.7 months (range 3 d–35.6 mo); breast cancer had the longest median survival (12.1 mo). Ten patients (7%) whose primary cancer was lung (3), kidney (3), sarcoma (2), prostate (1) or breast (1) died within 30 days postoperatively, and 88 had died at 12 months (62%). Univariate analyses yielded 8 significant predictors for survival: growth of the primary tumour (Tomita grade 1 v. grade 2 and 3), BMI, sex, preoperative SF-36 physical component, EQ-5D and ODI scores, as well as the presence of either visceral or extraspinal bony metastasis. The multiple regression analysis revealed that the Tomita grade (grade 1 v. grade 2 and 3, HR 2.81,  $p = 0.007$ ), the absence of visceral metastasis (HR 2.01,  $p = 0.0044$ ), and higher score on SF-36 physical component (HR 0.95,  $p < 0.0001$ ) were independent predictors for longer survival regardless of the selection method used (backward, forward or stepwise). **Conclusion:** Slow-growing tumour (Tomita grade 1), absence of visceral metastasis, and lower degree of preoperative physical disability, as reflected by a higher score on the SF-36 physical component questionnaire, are good prognostic factors for survival in selected patients who underwent surgical treatment for a focal symptomatic MESCC lesion.

**3.32: Surgical management of spinal osteoblastomas.** Anne Versteeg\*, Nicolas Dea†, Stefano Boriani‡, Peter P. Varga§, Alessandro Luzzati¶, Michael Feblings\*\*, Mark Bilsky††, Laurence Rhines‡‡, Jeremy Reynolds§§, Mark Dekutoski¶¶, Ziya Gokaslan\*\*\*, Niccole Germscheid†††, Charles Fisher†††. From the \*University Medical Center Utrecht, Utrecht, Netherlands; †Université de Sherbrooke, Sherbrooke, Que.; ‡Rizzoli Orthopaedic Institute, Bologna, Italy; the §National Center for Spinal Disorders and Buda Health Center, Budapest, Hungary; ¶Ortopedica Oncologica e Ricostruttiva del Rachide, Istituto Ortopedico Galeazzi, Milan, Italy; the \*\*University of Toronto and Toronto Western Hospital, Toronto, Ont.; ††Memorial Sloan Kettering Cancer Center, New York, N.Y.; ‡‡University of Texas MD Anderson Cancer Center, Houston, Texas; §§Oxford University Hospitals NHS Foundation Trust, Oxford, U.K.; the ¶¶CORE Institute, Phoenix, Ariz.; the \*\*\*Warren Alpert Medical School of Brown University, Providence, R.I.; †††AOSpine International, Davos, Switzerland; and the †††University of British Columbia, Vancouver, B.C.

**Background:** Osteoblastoma is a rare primary benign bone tumour with a predilection for the spinal column. Although of benign origin, osteoblastomas tend to clinically behave more aggressively. Due to the low incidence, evidence-based treatment guidelines and high-quality research are lacking, resulting in inconsistent treatments. The aim of this multicentre cohort study was to assess rates of local recurrence and mortality following surgical intervention for spinal osteoblastomas and to identify prognostic variables for local recurrence and mortality. **Methods:** A multicentre ambispective database of patients who underwent surgical intervention for spinal osteoblastoma was developed by the AOSpine Knowledge Forum Tumor. Patient data pertaining to demographics, diagnosis, treatment, cross-sectional survival and local recurrence were collected. Patients were analyzed in 2 cohorts based on the Enneking classification of the tumour: Enneking appropriate (EA) and Enneking inappropriate (EI). EA was defined by the final pathology margin matching the Enneking recommended surgical margin. If otherwise, it was defined as EI. **Results:** A total of 102 patients diagnosed with a spinal osteoblastoma were identified between November 1991 and June 2012. Twenty-eight patients were omitted from the analysis due to short follow-up or incomplete survival data, leaving 74 patients for final analysis. Thirteen (18%) patients suffered a local recurrence and 6 (8%) patients died during the study period. Local recurrence is strongly associated with mortality with a relative risk of 9.4 ( $p = 0.007$ ). When adjusting for Enneking appropriateness, the result was not significantly altered. No significant differences were found between the EA and EI groups for local recurrence and mortality. **Conclusion:** Upon evaluating the largest multicentre collection of spinal osteoblastomas, the application of the Enneking classification as a treatment guide for spinal osteoblastomas could not be confirmed. Considering the strong association between local recurrence and mortality, a complete radical resection, either through en-bloc or complete intralesional excision followed by adjuvant radiotherapy, is recommended for aggressive osteoblastoma.

**3.33: General population utilities for metastatic epidural spinal cord compression health states.** Markian Pabuta, Carl van Walraven, Doug Coyle, Joel Werier, Eugene Wai. From the University of Ottawa, Ottawa, Ont.

**Background:** A particularly disabling consequence of cancer is metastatic epidural spinal cord compression (MESCC). Few prospective studies on the treatment of MESCC have collected quality-adjusted life year weights (termed “utilities”). Utilities are an important summative measure that distils health outcomes to a single number that can be used by health care providers to counsel patients and policy-makers to make funding decisions. We sought to measure utilities for MESCC health states from the Canadian general population perspective. **Methods:** We recruited a sample of 822 adult Canadians from a market research company. Quota sampling was used to ensure that the participants were representative of the Canadian population in terms of age, sex, and province of residence. Participants were asked to rate 6 of the 32 MESCC health states using the validated self-administered online assessment of preferences (SOAP) tool. **Results:** Sixty-six percent of participants provided logical ratings (e.g., perfect health was rated higher than nonambulatory health states). Unadjusted mixed-effects regression analysis demon-

strated that participants valued ambulation, continence, pain, other symptoms, and independence equally. Adjusted analysis showed no significant association between utility valuations and age, sex or province of residence. **Conclusion:** This general population sample provided valid responses; the proportion of logical ratings was greater than that for the survey used to derive Canadian EQ-5D weights. These results demonstrate that from the societal perspective, physical function is valued equal to other facets of well-being. Ambulation and continence, which are dysfunctions addressed by surgery, are no more important than other attributes evaluated (pain, other symptoms, level of independence). Thus, formal utility elicitation can provide useful insights for patient counselling and health program planning.

**3.34: Instrumentation following decompression for spinal metastases — Is there a need for fusion in addition to internal fixation?** *Eoin Fenton\**, *Philippe Mercier†*, *Isb Bains\**, *W. Bradley Jacobs\**. From the \*University of Calgary, Calgary, Alta.; and †Saint Louis University, St. Louis, Miss.

**Background:** Decompression and instrumentation has proven beneficial to the neurologic outcome and quality of life for selected patients with spinal metastases. Due to the limited expected survival of this population and the lack of suitable local bone graft it remains unclear what, if any, fusion construct should be placed. This factor combined with postoperative radiotherapy that these patients invariably receive puts the vertebral column at risk. The failure rate for instrumentation in these patients varies widely with reports in the literature (within the last 10 yr) of 3.5%–43%. Our goal with this study is to clarify the need, if any, for fusion adjuncts. **Methods:** A retrospective chart review was conducted of consecutive patients who had undergone decompression and instrumentation for spinal metastases in a large multisurgeon spine practice to determine the rate of instrumentation failure. **Results:** A total of 104 procedures in 93 patients (38 female and 55 male) were performed over a 5-year period (2007–2011). The mean patient age was 61 (rangen 33–86 yr). The primary end point was last known follow-up, instrumentation failure or death (2–2924 d). Ten patients had multiple procedures but only 1 of those had a second procedure due to instrumentation failure (0.96%). Pedicle screw and rod ± synthetic cage constructs were augmented with graft (cement, autograft, BMP, allograft) in 62.5% of cases. No fusion or cement augmentation was performed in 37.5% of cases. In the 1 case of instrumentation failure, a Steinmann pin and methylmethacrylate were used as an anterior strut following a 2-level thoracic vertebrectomy. **Conclusion:** This study suggests that symptomatic failure of spinal instrumentation necessitating revision surgery in patients with spinal metastases is an uncommon occurrence (0.96%) despite the lack of bone graft in the constructs used to stabilize the vertebral column. This finding is of particular significance in patients whose primary malignancy is associated with longer survival.

**3.35: Do racial differences affect surgical outcomes in patients with degenerative cervical myelopathy? Results from the prospective, multicentre AOSpine International study on 479 patients.** *Naribito Nagosbi*, *Lindsay Tetreault*, *Hiroaki Nakashima*, *Aria Nouri*, *Michael Feblings*. From the University of Toronto, Toronto, Ont.

**Background:** Previous studies have highlighted racial differences in the pathology of degenerative cervical myelopathy (DCM), including a higher prevalence of ossification of the posterior longitudinal ligament (OPLL) in Asian populations. The objective of this study is to compare surgical outcomes between Caucasians and Asians with DCM and to determine whether race is an independent predictor of surgical outcomes. **Methods:** Patient demographics, causative pathology and surgical summaries were statistically compared between the 2 races. A mixed-model analytic approach was used to evaluate differences in surgical outcome between Caucasians and Asians, while controlling for relevant baseline characteristics and surgical factors. **Results:** Of the 479 DCM patients enrolled in the AOSpine CSM-International study, 324 (67.64%) were Caucasian and 106 East Asian (22.13%). Caucasians had significantly longer duration of symptoms and a greater number of comorbidities than East Asians. Surprisingly, there was no difference in the incidence of OPLL between the 2 races; however, a greater percentage of Caucasians in Asia exhibited OPLL than Caucasians in Europe or North America. With respect to outcome, patients from East Asia had significantly higher scores on the mJOA, Nurick and SF-36 version 2. After adjusting for key differences in patient characteristics and surgical features, these differences in functional status and quality of life between the 2 races remained significant. However, when adjusting for region the differences in the mJOA and SF-36 version 2 became nonsignificant. **Conclusion:** Based on these results, environmental or societal factors may influence surgical outcome. Race is therefore not an independent predictor of functional status or quality of life.

**3.36: Is preoperative duration of symptoms a significant predictor of functional status and quality of life outcomes in patients undergoing surgery for the treatment of degenerative cervical myelopathy?** *Lindsay Tetreault\**, *Branko Kopjar†*, *Jefferson Wilson\**, *Paul Arnold‡*, *Michael Feblings\**. From the \*University of Toronto, Toronto, Ont.; the †University of Washington, Seattle, Wash.; and the ‡University of Kansas Medical Center, Kansas City, Kansas.

**Background:** Longstanding compression of the spinal cord in patients with degenerative cervical myelopathy (DCM) may result in irreversible neural tissue damage. This study aims to analyze whether a longer duration of symptoms influences surgical outcomes and to determine the optimal timing for decompressive surgery. **Methods:** In total, 350 patients with symptomatic DCM were prospectively enrolled in either the CSM-North America or International study at 12 sites in North America. For each patient, pre- and postoperative functional status were evaluated at 12 months using the mJOA. Duration of symptoms was dichotomized into a “short” and “long” group at several cut-offs. An iterative mixed-model analytic approach procedure was used to evaluate differences in change scores on the mJOA between duration groups in 1-month increments. **Results:** Our cohort consisted of 201 men and 149 women, with a mean duration of symptoms of  $25.71 \pm 36.68$  months. In unadjusted analysis, patients with a duration of symptoms shorter than 4 months had significantly better functional outcomes based on the mJOA ( $p = 0.04$ ) than patients with a longer duration of symptoms ( $> 4$  mo). On average, patients with  $< 4$  months symptom duration improved by 3.71 on the mJOA, whereas those with a duration of

4 months only exhibited a 2.96 mean gain, difference of 0.75 (95% CI 0.03–1.47). Twelve months was identified as the next important cut-off beyond which patients had significantly worse outcomes on the mJOA. In the adjusted model, patients with < 12 months symptom duration improved by 3.37 on the mJOA, whereas those with a duration 12 months or longer exhibited a 2.85 mean gain, difference of 0.52 (95% CI 0.01–1.03). **Conclusion:** Patients who are operated on within 4 months of symptom presentation have better mJOA outcomes. It is recommended that patients with DCM are diagnosed in a timely fashion and referred early for surgical consultation.

**3.37: Surgery for degenerative cervical myelopathy from an economic and outcome perspective: a cost-utility analysis of the combined data from the AOSpine North America and International studies.** *Christopher Witw\*, Lindsay Tetreault\*, Branko Kopjar†, Eric Massicotte\*, Michael Feblings\**. From the \*University of Toronto, Division of Neurosurgery, Toronto, Ont.; and the †Department of Health Services, University of Washington, Seattle, Wash.

**Background:** Surgery for degenerative cervical myelopathy (DCM) has been shown to improve neurologic status and quality of life, yet the intervention is costly. Concerns regarding sustainability of health care delivery have placed value-based purchasing at the forefront of policy decision-making. We aim to estimate the lifetime incremental cost-utility of surgery for DCM, which may help guide future health care resource allocation. **Methods:** This evaluation was based on prospective data from patients participating in 1 of 2 multicentre international studies who had surgery for DCM at a single centre between 2005 and 2011. SF-6D health utility scores were modelled over 6, 12 and 24 months following surgery. Individual quality-adjusted life year (QALY) gains were calculated from the area under the curve; lifetime estimates were discounted at 3%/year. Costs from a hospital as a payer perspective were obtained from a local microcosting database for each individual. The costs captured include total direct (operating room, nursing, laboratory, pharmacy and imaging) and indirect costs (administrative and support departments). Multiway sensitivity analysis included variation of the discount rates (0%–5%) and revision rates (1.5%–2.5%). Costs are reported in Canadian dollars and inflated to 2015 values. **Results:** The analysis included 171 patients: mean age 58.2 ± 12.0 years; baseline modified Japanese Orthopaedic Association score 12.4 ± 2.7. At 2 years, utility gain was 0.083 (95% CI 0.063–0.103,  $p < 0.0001$ ). Lifetime discounted QALY gain was 1.573 (95% CI 1.320–1.825,  $p < 0.0001$ ). The mean direct costs of medical treatment were estimated at \$19 217 ± \$12 404. Median estimated lifetime incremental cost-utility ratio (ICUR) was \$13 032/QALY. Multiway sensitivity analysis provided a range of \$6,552/QALY to \$22 307/QALY. This falls within general willingness-to-pay thresholds (< \$50 000/QALY gained). **Conclusion:** Surgery for DCM is associated with significant improvements in health utility and is cost-effective from a hospital payer perspective.

**3.38: Laminoplasty versus laminectomy and fusion to treat cervical spondylotic myelopathy: outcomes of the prospective multicentre AOSpine North America and International CSM studies.** *Carlo Santaguida\*, Michael Feblings†, Branko Kopjar‡, Paul Arnold§, Helton Defino¶, Sbasbank Kale\*\*, S. Tim Yoon††, Giuseppe Barbagallo‡‡, Ronald Bartels§§, Qiang*

*Zhou¶¶, Alexander Vaccaro\*\*\*.* From \*McGill University, Montreal, Que.; the †University of Toronto, Toronto, Ont.; the ‡University of Washington, Seattle, Wash.; the §University of Kansas, Kansas City, Kansas; the ¶University of Sao Paulo Ribeirao Preto, Brazil; \*\*AIIMS, New Delhi, India; ††Emory University, Atlanta, Ga.; ‡‡Universitaria Policlinico Vittorio Emanuele, Catania, Italy; §§Radboud University, Nijmegen, Netherlands; ¶¶Southwest Hospital, Chongqing, China; and \*\*\*Thomas Jefferson University, Philadelphia, Pa.

**Background:** We present the results from the pooled analysis of the 2 largest prospective cervical spondylotic myelopathy (CSM) studies to determine the outcomes of cervical laminectomy and fusion (CLF) and laminoplasty (CLP). **Methods:** The AOSpine North America and International prospective multicentre studies enrolled 166 participants who underwent CLF and 100 patients who underwent CLP from a pool of 757 patients. In total, 83% of participants completed 1 year follow-up. Primary outcomes included Nurick Score, mJOA, Neck Disability Index (NDI), and secondary outcomes included the SF-36 version 2 physical (SF-36 PCS) and mental component (SF-36 MCS) scores at 1 year following treatment. The data were analyzed by 1-way analysis of variance (ANOVA) and analysis of covariance (ANCOVA), adjusting for covariates: sex, age, smoking, operative level, region and baseline scores. **Results:** Study participants who underwent a CLF were found to have a mean (range) improvement in Nurick score 0.90 (0.57–1.23), mJOA 2.45 (1.55–2.71), NDI 9.77 (5.07–14.47), SF-36 PCS 4.85 (2.47–7.23), and SF-36 MCS 5.15 (2.07–8.23) at 1 year following treatment. Participants who underwent CLP were found to have a mean (range) improvement in Nurick score 1.00 (0.60–1.41), mJOA score 2.51 (1.78–3.25), NDI improvement of 9.72 (4.17–15.26), SF-36 PCS 3.87 (0.84–6.90), SF-36 MCS 6.06 (2.58–9.53) at 1 year following treatment. The adjusted analysis did not reveal a statistically significant difference in outcome measures between surgical groups. **Conclusion:** CLF and CLP were effective in the treatment of CSM. The pooled analysis of these prospective multi-centre CSM studies revealed no difference in outcome measures (mJOA, Nurick, NDI, SF-36 PCS and MCS) between patients treated with CLF and CLP.

**3.39: The impact of spinal manipulation on lower extremity motor control in lumbar spinal stenosis patients: a single-blind randomized clinical trial.** *Mina Aziz, Michael Johnson, Steven Passmore, Michael Goytan, Cheryl Glazebrook.* From the University of Manitoba, Winnipeg, Man.

**Background:** Spinal manipulation (SM) can offer lumbar spinal stenosis (LSS) patients a degree of pain relief and improve self-reported disability. Our objective is to quantify the impact of a single SM intervention on patients with LSS using a Fitts' Law lower extremity movement task. Our findings will inform surgeons of potential objective treatment outcomes when considering nonoperative care. We hypothesize that patients who receive spinal manipulation will demonstrate improved motor performance compared with a nonintervention (NI) group. **Methods:** Participants with LSS ( $n = 14$ ) performed baseline testing and underwent a covariate-adaptive randomization. Each participant performed a foot-pointing task to 4 targets with different indexes of difficulty. Participants completed 10 trials per target, per foot,



resulting in 80 total trials both pre- and postintervention. Pain, lumbar range of motion (LROM) and motor performance were assessed at baseline and following lumbar SM or NI. Experimenters were blinded to patient group allocation. **Results:** Significant main effects for movement time (MT), peak velocity, time to peak velocity and peak acceleration were observed across task difficulty as predicted by Fitts' Law. Planned comparisons of the MT main effect revealed significant differences between the 2 most difficult targets post-SM ( $M = 740$  ms,  $SD = 230$  and  $M = 780$  ms,  $SD = 240$ ;  $t_c = 3.042$ ,  $p = 0.02$ ). For all other comparisons, gross movements required to attain appropriate target amplitude superseded any precision movements associated with coordinated movement to targets of different sizes. No significant differences in pain or LROM were found within or between groups. **Conclusion:** Participants undergoing SM demonstrated immediate improvement in MT, specifically in their motor performance in the most challenging movement contexts. There were no immediate differences in pain, LROM or kinematic performance. In the future, research on the impact of SM on LSS patients should quantify the impact of a course of care (multiple SM treatments over multiple days) which more closely reflects nonoperative clinical practice.

**3.40: Predictors of improved pain, function and quality of life following elective lumbar spine fusion surgery.** *Morsi Khasban<sup>\*</sup>, Jeff Golan<sup>\*</sup>, Greg McIntosh<sup>†</sup>, Joy Barker<sup>\*</sup>, Michael Weber<sup>\*</sup>.* From McGill University, Montreal, Que.; and the <sup>†</sup>Canadian Spine Society, Markdale, Ont.

**Background:** The main indication for elective lumbar spine fusion is improving pain and life quality, yet outcomes of these procedures may vary widely. In order to identify predictors of improved pain levels, function, and quality of life, we analyzed elective lumbar fusion surgery cases using CSORN. **Methods:** All cases of elective lumbar spine fusion entered into CSORN between October 2008 and September 2015 were investigated. We analyzed demographic, preoperative and intraoperative parameters. Change in numeric pain rating visual analogue scale (VAS) for back and leg pain, change in EuroQoL-5 Dimension Questionnaire (EQ-5D) and change in the ODI from baseline to 3 months following surgery were calculated. The required data were available for 1083 cases. Multivariable linear regression was used with a data-splitting technique to develop and validate the multivariable models. A 67% random sample of the data set was used for model development, and the entire data set was used for model validation. **Results:** Principal pathology of spinal stenosis, the presence of spondylolisthesis and fusions above the sacrum predicted increased improvement of VAS rating for back and leg pain. Principal pathology other than deformity and the presence of extra comorbidities were associated with increased improvement in both ODI and the EQ-5D scores. Fusion of less than 3 levels and smoking predicted increased improvement of ODI score and procedures without osteotomy predicted improved EQ-5D score ( $p < 0.05$ ). **Conclusion:** Our study identified a number of predictors of improved outcome. The results shed light on patient selection criteria and on the potential for bias. The improved outcome in smokers and patients with several comorbidities may be explained by the application of rigid selection criteria in these populations and the selection of patients with more surgically amenable pathologies to justify intervention.

**3.41: Objective measurement of free-living physical activity (performance) in lumbar spinal stenosis: Are physical activity guidelines being met?** *Cbristy Tomkins-Lane<sup>†\*</sup>, Richard Hur<sup>‡</sup>, Justin Norden<sup>†</sup>, Aman Sinha<sup>†</sup>, Matthew Smuck<sup>†</sup>.* From <sup>\*</sup>Mount Royal University, Calgary, Alta.; <sup>†</sup>Stanford University, Palo Alto, Calif.; and the <sup>‡</sup>University of Calgary, Calgary, Alta.

**Background:** It is likely that people with lumbar spinal stenosis (LSS) would benefit from physical activity, yet we do not have disease-specific guidelines, nor do we fully understand the nature of free-living physical activity (performance) in LSS. Care providers could endorse the 2008 US Physical Activity Guidelines, but we do not know if this is realistic for people with LSS. We sought to determine the proportion of individuals with LSS meeting the 2008 US Physical Activity Guidelines and to better understand the nature of performance in LSS. **Methods:** Retrospective analysis of the Lumbar Spinal Stenosis Accelerometry Database, which includes 75 people with LSS diagnosed clinically and on imaging, with 4 valid days of accelerometry data. We determined the proportion of individuals meeting the 2008 US Physical Activity Guidelines of at least 150 minutes of moderate-vigorous (MV) activity per week, in bouts of 10 min or more. We also used the novel physical performance analysis designed by our group to determine time spent in varying intensities of activity, with a focus on light activity. **Results:** We analyzed data from 75 individuals — 37% of them male — with a mean age of  $68 \pm 9$  years. Three people (4%) were considered meeting guidelines (at least 150 MV min/wk), 16 (21%) were considered low active (1–149 MV min/wk), and 56 (75%) were considered inactive (MV min/wk). The average time spent in sedentary activity was 82%, and of time spent in nonsedentary activity (99.6%) was in light activity. **Conclusion:** People with LSS are extremely inactive with only 4% meeting physical activity guidelines. There is an obvious need to intervene in people with LSS to improve sedentary behaviour and prevent diseases of inactivity. Results of this study suggest that a focus on light intensity activity may be most appropriate. This study is one step toward a personalized medicine approach for people with LSS, focusing on increasing physical function.

**3.42: Two-year follow-up in spine clinical research: An adequate benchmark?** *Firoz Miyajji<sup>\*\*</sup>, Sameer Desai<sup>\*\*</sup>, Amer F. Samdani<sup>†</sup>, Suken A. Shah<sup>‡</sup>, Jahangir Asghar<sup>§</sup>, Burt Yaszay<sup>¶</sup>, Harry L. Shufflebarger<sup>§</sup>, Randal R. Betz<sup>\*\*</sup>, Peter Newton<sup>††</sup>.* From the <sup>\*</sup>BC Children's Hospital, Vancouver, B.C.; the <sup>†</sup>Shriners' Hospitals for Children, Philadelphia, Pa.; the <sup>‡</sup>Nemours/Alfred I. DuPont Hospital for Children, Wilmington, Del.; the <sup>§</sup>Nicklaus Children's Hospital, Miami, Fla.; <sup>¶</sup>Children's Specialists, San Diego, Calif.; the <sup>\*\*</sup>Institute for Spine and Scoliosis, Lawrenceville, N.J.; and the <sup>††</sup>Rady Children's Hospital, San Diego, Calif.

**Background:** Most long-term follow-up studies report retrospective data, the quality of which remain limited due to their inherent biases. Prospective databases may overcome these limitations; however, feasibility and costs limit their application. To date there exists a paucity of evidence-based literature on which recommendations can be made for the ideal length of follow-up for spinal deformity research. Therefore, our aim was to evaluate the added value of follow-up of patients beyond 2 years following

surgery for adolescent idiopathic scoliosis (AIS). **Methods:** A database registry evaluating surgical outcomes for all consecutive AIS patients with postoperative data points of 6 months, 1 year, 2 years and 5 years was analyzed. Surgeon-reported complications, SRS-22 scores and radiographic data were evaluated. Complications requiring surgical or medical intervention were compared between patients in whom complications developed within 2 years to those in which newly developed complications occurred between 2 and 5 years. **Results:** In total, 536 patients were analyzed. SRS-22 scores significantly improved at 2 years postoperatively with no change at 5-year follow-up. The overall complication rate was 33.2%, with most occurring within 2 years (24.8%). The rate of complications occurring later than 2–5 years requiring intervention was significantly lower than those requiring intervention within 2 years of surgery (4.7% v. 9.7%,  $p < 0.001$ ); however, this was not negligible. The most common newly observed complication beyond 2 years was pain (1.9%), followed by surgical site infection (SSI; 1.3%) and implant issues (0.56%). There were no significant differences in the rates of crankshaft ( $p = 0.48$ ), implant issues ( $p = 0.56$ ), pseudarthrosis ( $p = 0.19$ ) and SSI ( $p = 0.13$ ) between the 2 time points. **Conclusion:** Although most complications following AIS surgery occur within 2 years, a non-negligible rate of newly observed complications occur at more than 2–5 years postoperatively. Specifically, crankshaft, pseudarthrosis, implant issues and SSI have similar rates of occurrence at these 2 time points. Our study emphasizes the added value of prospective follow-up beyond 2 years in AIS.

**3.43: The impact of presurgical self-reported exercise patterns on postsurgical outcomes.** *Michael Johnson\**, *Steven Passmore\**, *James McCammon\**, *Michael Goytan\**, *Greg McIntosh†*. From the \*University of Manitoba, Winnipeg, Man.; and †CSORN, Hamilton, Ont.

**Background:** There is evidence that preoperative physical fitness impacts surgical outcomes — specifically, supportive evidence for exercise preceding abdominal, cardiovascular and spine surgery. Walking ability before decompression surgery improves outcomes. To our knowledge there are no papers on self-reported exercise frequency as a predictor of thoracolumbar surgery outcomes. We predict patients who report exercise before surgical intervention will demonstrate decreased pain and disability but increased perceived health state following surgery, compared with patients who do not exercise. **Methods:** Study design was a retrospective analysis of prospectively collected national spine registry data. Data were collected from the CSORN registry. Inclusion criteria specified all thoracolumbar patients who proceeded to spine surgery since CSORN registry inception who completed the pre- and postoperative outcome measures up to 12 months postsurgery ( $n = 992$ ). Questionnaire measures included numeric rating scales for back and leg pain, health state and ODI. Exercise frequency was self-reported as “none” ( $n = 637$ ) versus “some” ( $n = 355$ ). Student *t* tests were used to compare the mean scores of the outcome measures. Differences in the measures pre- and postoperatively were compared with the minimal clinically important differences (MCIDs) in other spine surgery literature. **Results:** Those who reported “some” exercise had more favourable scores pre- and postoperatively than those who reported “none.” Significant differences were noted 6 months postoperatively for back pain, leg pain, health state and

ODI, and at 12 months postoperatively for health state (“some”  $73.62 \pm 18.42$ , “none”  $68.18 \pm 18.56$ ,  $p = 0.003$ ), and ODI (“some”  $20.65 \pm 17.32$ , “none”  $25.07 \pm 18.97$ ,  $p < 0.001$ ). The MCIDs were similar to previous studies considering questionnaire outcomes for thoracolumbar spine surgery. **Conclusion:** Patients who reported at least “some” exercise had consistently more favourable scores in outcome measures preoperatively and 6 months postsurgery. Beyond the 6-month findings at least some presurgical exercise decreases disability and improves health state up to 12 months post-thoracolumbar spine surgery.

**3.44: Baseline and postoperative outcomes in patients undergoing surgery for degenerative lumbar spondylolisthesis: a comparison study between single-payer and multitier health care systems.** *Jin Tee\**, *Charles Fisher†*. From the \*University of British Columbia, Vancouver, B.C.; and the †National Trauma Research Institute, Melbourne, Australia.

**Background:** The first objective is to compare pre- and postoperative disease-specific and generic HRQoL measures in surgical degenerative lumbar spondylolisthesis (DLS) patients. The second objective is to compare outcomes of surgical DLS patients in single-payer versus multi-tier health care systems. **Methods:** The CSORN registry was queried from 2004 to 2015. Baseline and postoperative data were (1) demographic, (2) specific expectation data (SED), (3) back/leg-pain scores, and (4) ODI. Matching CSORN data were compared with the Spine Patient Outcomes Research Trial (SPORT) DLS surgical arm cohort. Statistical analysis was bivariate inferential regression modelling. **Results:** The CSORN query returned 471 patients. The SPORT cohort had 368 patients. The CSORN cohort was younger (60.9 v. 64.7,  $p < 0.01$ ), had fewer females (62% v. 69%,  $p = 0.03$ ), and had more smokers (20% v. 9%,  $p < 0.01$ ). The SPORT cohort had more patients in the workforce (36% v. 28%,  $p = 0.02$ ) and more workers’ compensation patients (9% v. 4%,  $p < 0.01$ ). The CSORN cohort had poorer baseline function with higher ODI scores (48.2 v. 45.0,  $p < 0.01$ ) and had more patients who were symptomatic for 6 months or longer (95% v. 62%,  $p < 0.01$ ). The CSORN cohort was more satisfied with the surgical results at both the 3-month and 1-year postoperative mark ( $p < 0.01$ ). The SPORT cohort was less disabled at the 3-month postoperative mark; however, the CSORN cohort members were less disabled at the 1-year postoperative mark ( $p < 0.01$ ). **Conclusion:** Patients with degenerative spondylolisthesis who undergo surgery have better 1-year outcomes in a single-payer health care system than in a multitier health care system, despite having poorer baseline disease-specific disability and being symptomatic for longer.

**3.45: An exploration of the inter-relationships between low back pain, obesity, inflammation and diabetic status.** *Darren M. Roffey\**, *Abdulghader Alfasi†*, *Emile L. Hashem‡*, *Gabrielle D. Papineau§*, *Stephen P. Kingwell§*, *Eugene K. Wai†§*. From the \*University of Ottawa Spine Program, The Ottawa Hospital, Ottawa, Ont.; the †Clinical Epidemiology Program, Ottawa Hospital Research Institute, Ottawa, Ont.; the ‡Faculty of Medicine, University of Ottawa, Ottawa, Ont.; and the §Division of Orthopaedic Surgery, Department of Surgery, University of Ottawa, The Ottawa Hospital, Ottawa, Ont.

**Background:** LBP is a common musculoskeletal disorder. Numerous potential sources of LBP have been identified, but the etiology remains ambiguous. Many studies have shown an association between obesity and LBP due to combinations of mechanical, structural, metabolic and behavioural factors. Recently, associations between 1) obesity and inflammation, 2) inflammation and pain signalling, and 3) LBP and inflammation have also been postulated. Our objective was to elucidate whether inflammatory, diabetic status and obesity-related measures are related to LBP. **Methods:** In this retrospective chart study, we collected data on 62 consecutive, nonsurgical, chronic LBP patients who presented for a consultation appointment with an orthopedic spine surgeon. Patients completed pain questionnaires (i.e., 0–10 visual analogue score) and provided demographic details (e.g., height, weight, working status, exercise levels). Blood work was collected at this baseline appointment, and the following inflammatory and diabetic status markers were tested: white blood cell (WBC), erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), and hemoglobin A1c (HbA1c). **Results:** We found 47.5% of patients had ESR values (mean  $15.7 \pm 9.7$  mm/h) above normative values (6.0 mm/h). Similarly, 47.1% of patients had HbA1c values (mean  $7.3 \pm 2.1\%$ ) above normative values (6.0%). Patients with high WBC, ESR, CRP or HbA1c values were more likely to be female, in their mid-50s, nonsmokers, have a BMI around 26 kg/m<sup>2</sup> and clearly indicated predominant back pain (range 7.5–8.7 out of 10) versus left or right leg pain (range 2.8–5.9 out of 10). **Conclusion:** Almost 50% of nonsurgical, chronic LBP patients presented with a significant inflammatory or prediabetic status. Larger studies need to be conducted to investigate the impact of systemic inflammation and/or poorly controlled blood glucose levels as contributors to LBP. Exploring the impact of exercise and its mediating effects in these patients may also be warranted.

## POSTERS FOR PRESENTATION

**P01: Methylprednisolone for the treatment of patients with acute spinal cord injuries: a systematic review and meta-analysis.** *Nathan Evaniew\**, *Emilie P. Belley-Côté\**, *Nader Fallah<sup>†‡</sup>*, *Vanessa K. Noonan<sup>†‡</sup>*, *Carly S. Rivers<sup>†‡</sup>*, *Marcel F. Dvorak<sup>†‡</sup>*. From \*McMaster University, Hamilton, Ont.; the <sup>†</sup>University of British Columbia, Vancouver, B.C.; and the <sup>‡</sup>Rick Hansen Institute, Vancouver, B.C.

**Background:** Previous meta-analyses of methylprednisolone for patients with acute traumatic spinal cord injuries (tSCIs) have not addressed confidence in pooled effect estimates, and new primary studies have recently been published. We performed a systematic review and meta-analysis to determine whether methylprednisolone improves motor recovery and is associated with increased risks for adverse events. **Methods:** We searched MEDLINE, EMBASE and the Cochrane Library for eligible RCTs and controlled observational studies. Two reviewers independently screened articles, extracted data and evaluated risk of bias. We pooled outcomes from RCTs and controlled observational studies separately. We used the Grades of Recommendation, Assessment, Development and Evaluation (GRADE) approach to evaluate confidence. **Results:** We included 4 RCTs and 17 observational studies. Methylprednisolone did not increase long-term motor score recovery (2 RCTs: 335 participants, mean difference [MD]  $-1.11$ , 95% CI  $-4.75$  to  $2.53$ ,  $p =$

$0.55$ , low certainty; 2 observational studies: 528 participants, MD  $1.37$ , 95% CI  $-3.08$  to  $5.83$ ,  $p = 0.55$ , very low certainty) or improvement by at least 1 motor grade (3 observational studies: 383 participants, risk ratio [RR]  $0.84$ , 95% CI  $0.53$  to  $1.33$ ,  $p = 0.46$ , very low certainty). Evidence from 2 RCTs demonstrated superior short-term motor score improvement if methylprednisolone was administered within 8 hours of injury (2 RCTs: 250 participants; MD  $4.46$ , 95% CI  $0.97$  to  $7.94$ ,  $p = 0.01$ ; low certainty), but the risk of bias and imprecision limit confidence in these findings. Observational studies demonstrated a significantly increased risk for gastrointestinal bleeding (9 studies: 2857 participants, RR  $2.18$ , 95% CI  $1.13$  to  $4.19$ ,  $p = 0.02$ , very low confidence), but RCTs did not. **Conclusion:** Pooled evidence does not demonstrate a significant long-term benefit for methylprednisolone in patients with acute tSCIs and suggests it may be associated with increased gastrointestinal bleeding. These findings support current guidelines against routine use, but strong recommendations are not warranted because confidence in the effect estimates is limited.

**P02: The relationship between preoperative clinical presentation and quantitative MRI features in patients with degenerative cervical myelopathy.** *Aria Nouri\**, *Lindsay Tetreault\**, *Kristian Dalzell<sup>†</sup>*, *Juan Jose Zamorano<sup>‡</sup>*, *Michael Feblings\**. From the \*University of Toronto, Toronto, Ont.; <sup>†</sup>Christchurch Hospital and Burwood Spinal Unit, Christchurch, New Zealand; and <sup>‡</sup>Hospital del Trabajador, Santiago, Chile.

**Background:** Degenerative cervical myelopathy (DCM) encompasses a group of degenerative conditions of the cervical spine, including cervical spondylotic myelopathy (CSM), that result in spinal cord pathology through static and dynamic injury mechanisms. While there are a constellation of degenerative findings that can present in patients with DCM on MRI, the clinical significance of these findings remains a subject of controversy and discussion. **Methods:** In total, 114 patients enrolled in the prospective and multicentre AOSpine North America CSM study with complete MRI and clinical data were evaluated. Patients were enrolled if they had  $\geq 1$  clinical signs of myelopathy. Mid-sagittal MRIs were assessed for maximum spinal cord compression (MSCC) and maximum cord compromise (MCC). Additionally, the presence of  $T_1$  and  $T_2$  signal changes, as well as the degree of  $T_2$  signal hyperintensity deviation were evaluated. MRI features were then statistically related with the presence of upper and lower limb neurologic symptoms as well as generalized neurologic dysfunction. **Results:** Numb hands ( $p = 0.01$ ) and Hoffmann's sign ( $p = 0.003$ ) were associated with greater MSCC; broad-based, unstable gait ( $p = 0.042$ ), impairment of gait ( $p = 0.008$ ) and Hoffmann's sign ( $p = 0.013$ ) were associated with greater MCC; numb hands ( $p = 0.037$ ), Hoffmann's sign ( $p = 0.017$ ), Babinski sign ( $p = 0.002$ ), lower limb spasticity ( $p = 0.011$ ), Lhermitte's phenomenon ( $p = 0.045$ ), hyperreflexia ( $p = 0.004$ ), and presence of  $T_1$  hypointensity were associated with a greater deviation of signal intensity on  $T_2$  MRI. Patients with the presence of  $T_2$  signal hyperintensity also had greater MSCC ( $p < 0.001$ ) and MCC ( $p < 0.001$ ). **Conclusion:** MSCC and MCC were predominately associated with upper limb and lower limb manifestations, respectively; SCR was associated with upper limb, lower limb and general neurologic deficits.

Hoffmann's sign was more common in patients with a greater MSCC, MCC and SCR. Lhermitte's presented more often in patients with a lower SCR and thus may serve to indicate mild pathology and potential for reversibility.

**P03: Change in function, pain and quality of life following structured nonoperative treatment in patients with degenerative cervical myelopathy: a systematic review.** *Lindsay Tetreault\**, *Mobammed Shamji\**, *John Rbee†*, *Jefferson Wilson\**, *Ian Andersson‡*, *Anna Dembek‡*, *Krystle Pagarigan§*, *Joseph Dettori§*, *Michael Feblings\**. From the \*University of Toronto, Toronto, Ont.; †Emory University, Atlanta, Ga.; ‡University of Puget Sound, Tacoma, Wash.; and §Spectrum Research Inc., Tacoma, Wash.

**Background:** We sought to conduct a systematic review of the literature to determine (1) the change in function, pain and quality of life following structured nonoperative treatment for degenerative cervical myelopathy (DCM); (2) the variability of change in function, pain and quality of life following different types of structured nonoperative treatment; (3) the differences in outcomes observed between certain subgroups; and (4) negative outcomes and harms resulting from structured nonoperative treatment. **Methods:** A systematic search was conducted for articles published between Jan. 1, 1950, and Feb. 9, 2015. Studies were included if they evaluated outcomes following structured nonoperative treatment, including therapeutic exercise, manual therapy, cervical bracing and/or traction. Outcomes of interest were functional status, pain in upper extremities and neck, quality of life, and/or conversion to surgery. The quality of each study was evaluated using the Newcastle–Ottawa Scale, and the strength of the overall body of evidence was rated using guidelines outlined by the GRADE. **Results:** There is very low evidence to suggest that structured nonoperative treatment for DCM results in a positive or negative change in function, pain and quality of life as evaluated by the Japanese Orthopaedic Association (JOA) score. There is also limited evidence from 3 studies indicating that early structured nonoperative treatment (duration of symptoms < 1 yr) may be associated with positive clinical outcomes. There were no studies that directly compared structured nonoperative treatment types and no studies that explored outcomes based on patient subgroups. The rate of conversion to surgery was reported to be between 23%–54% in mostly cases of mild or moderate myelopathy (JOA ≥ 12). **Conclusion:** There is a lack of evidence to determine the role of nonoperative treatment in patients with DCM. However, in most studies patients did not achieve clinically significant gains in functional status following structured nonoperative treatment. Furthermore, rates of failed conservative treatment were between 23% and 54%.

**P04: Tobacco smoking and outcomes following surgical decompression in patients with symptomatic degenerative cervical myelopathy.** *Paul Arnold\**, *Branko Kopjar†*, *Lindsay Tetreault‡*, *Hiroaki Nakashima‡*, *Michael Feblings‡*. From the \*University of Kansas Medical Center, Kansas City, Kansas; †University of Washington, Seattle, Wash.; and ‡University of Toronto, Toronto, Ont.

**Background:** Tobacco smoking has negative effects at the cellular level and has been associated with poor outcomes following anterior discectomy and fusion for radiculopathy. However, the

impact of smoking on outcomes in patients undergoing surgery for degenerative cervical myelopathy (DCM) has not been extensively evaluated. This study aims to analyze the impact of tobacco smoking on functional and quality of life outcomes in DCM patients. **Methods:** In total, 749 patients with symptomatic DCM underwent surgical decompression at 24 global sites. Prospective data were collected for each participant, including smoking status. Preoperatively and at each follow-up, patients were evaluated using the mJOA, Nurick score, Neck Disability Index (NDI), and Short-Form-36 (SF-36). Analysis of covariance was used to evaluate differences in outcomes at 24 months between smokers and nonsmokers, while controlling for relevant baseline characteristics. **Results:** There were 547 (73.03%) nonsmokers and 202 (26.97%) smokers. Smokers were on average younger ( $53.40 \pm 9.36$  yr) than nonsmokers ( $57.42 \pm 12.45$  yr,  $p = 0.0200$ ) and had worse preoperative quality of life based on the NDI, SF-36 physical (PCS) and mental component scores (MCS;  $p < 0.1$ ). There were no differences between the groups with respect to preoperative mJOA or Nurick, sex, race, duration of symptoms, causative pathology and number of operated levels. At 12 months following surgery, improvements in mJOA, NDI, SF-36 version 2 PCS scores were significantly better in nonsmokers than in smokers. Specifically, mJOA, NDI and SF-36 PCS outcomes were 15.59%, 31.61% and 28.57% lower in smokers than nonsmokers. Following adjustment for confounders, these differences remained statistically significant. There were no differences in rates of complications between smokers and nonsmokers. However, smokers (4.95%) were more likely to undergo subsequent surgeries than nonsmokers (2.56%), although this association did not reach statistical significance ( $p = 0.0991$ ). **Conclusion:** Smoking is strongly associated with suboptimal surgical outcomes in patients with DCM.

**P05: Predicting the minimum clinically important difference in patients undergoing surgery for the treatment of degenerative cervical myelopathy.** *Lindsay Tetreault\**, *Branko Kopjar†*, *Paul Arnold‡*, *Mark Kotter\**, *Michael Feblings\**. From the \*University of Toronto, Toronto, Ont.; †University of Washington, Seattle, Wash.; and ‡University of Kansas Medical Center, Kansas City, Kansas.

**Background:** The minimal clinically important difference (MCID) is defined as the minimum change in a measurement that a patient would identify as beneficial. Before undergoing surgery, patients are likely to inquire about the ultimate goals of the operation and of their chances of experiencing meaningful improvements. The objective of this study was to define significant predictors of achieving an MCID on the mJOA at 2 years following surgery for the treatment of degenerative cervical myelopathy (DCM). **Methods:** In total, 757 patients were prospectively enrolled in either the AOSpine North America or International study at 26 global sites. Data were collected for each participant, including demographic information, symptomatology, medical history, causative pathology and functional status. Univariate log-binomial regression analyses were conducted to evaluate the association between preoperative clinical factors and achieving MCID on the mJOA. Modified Poisson regression using robust error variances was used to create the final multivariate model and compute the relative risk for each predictor. **Results:** The sample consisted of 463 (62.31%) men and 280 (37.69%) women, with an average

age of  $56.48 \pm 11.85$  years. At 2 years following surgery, the mean change in functional status was  $2.71 \pm 2.89$ . A total of 481 (70.01%) patients exhibited meaningful gains on the mJOA, whereas 206 (29.98%) failed to improve by  $\geq$  MCID. Based on univariate analysis, the significant predictors of achieving the MCID on the mJOA were younger age, female sex, shorter duration of symptoms, non-smoking status, a lower comorbidity score and absence of cardiovascular disease, absence of upgoing plantar responses, lower limb spasticity and broad-based unstable gait. The final model included age (RR 0.991,  $p < 0.0001$ ), smoking status (RR 0.836,  $p = 0.0040$ ), broad-based unstable gait (RR 0.872,  $p = 0.0044$ ) and duration of symptoms (RR 0.943,  $p = 0.0003$ ). **Conclusion:** Patients are less likely to exhibit clinically meaningful improvements if they smoke, are older, have broad-based unstable gait and have a longer duration of symptoms.

**P06: Timing of decompression in patients with acute spinal cord injury: a systematic review.** *Michael Feblings\**, *Jefferson Wilson\**, *Paul Arnold†*, *Christopher Shaffrey‡*, *Mohammed Shamsji*, *Thomas Mroz§*, *Andrea Skelly¶*, *Jens Chapman\*\**, *Lindsay Tetreault\**, *Bizhan Aarabi††*, *Steve Casha††*. From the \*University of Toronto, Toronto, Ont.; the †University of Kansas Medical Center, Kansas City, Kansas; the ‡University of Virginia, Charlottesville, Va.; the §Cleveland Clinic, Cleveland, Ohio; ¶Spectrum Research Inc., Tacoma, Wash.; the \*\*Swedish Neuroscience Institute, Seattle, Wash.; the ††University of Maryland, Baltimore, Md.; and the ††Foothills Medical Centre, Calgary, Alta.

**Background:** We sought to perform a systematic review to assess the comparative effectiveness and safety of early ( $\leq 24$  h) versus later decompression ( $> 24$  h) in adults with acute tSCI. **Methods:** A systematic search was conducted for literature published through Nov. 6, 2014. Included studies were critically appraised, and GRADE methods were used to determine the overall strength of evidence. Based on expert clinical opinion, an improvement of 2 or more grades for Frankel or ASIA grades or 5-point improvement in ASIA motor score was considered a priori to represent clinically meaningful improvement. **Results:** Across studies and injury levels, early surgical decompression was not consistently associated statistically with clinically important improvement in neurologic status. Isolated studies reported statistically significant and clinically important improvement at 6 months for cervical injury and following discharge from inpatient rehabilitation, but not at other time points in a population composed of injury at any level. Another study reported a statistically significant 6-point improvement in ASIA score only among patients with ASIA Impairment Scale (AIS) B, C or D, but not for those with AIS A. In 1 study of acute tSCI without instability, a clinically and statistically meaningful improvement in total motor scores was seen at 6 months but not 12 months, and there were no statistical differences in AIS up to 12 months. Safety and harms were reported in only 3 studies; although no statistical differences between early and late decompression were seen. **Conclusion:** The overall strength of evidence across studies was low to very low that early decompression may lead to clinically important improvement in neurologic status in some instances. Although no statistical or clinically significant differences were noted between early and late groups, firm conclusions regarding the safety of early versus delayed surgical decompression are difficult given small sample sizes.

**P07: Defining the pathway to definitive care and surgical decompression after traumatic spinal cord injury: results of a Canadian population-based cohort study.** *Jefferson Wilson\*\**, *Susan Jaglal†*, *Jennifer Voth†*, *Albert Yee†*, *Michael Feblings†*. From \*\*Thomas Jefferson University, Philadelphia, Pa.; and the †University of Toronto, Toronto, Ont.

**Background:** Our objectives were to characterize and quantify patients' pathway to definitive care and to surgery after tSCI, and to identify patient-specific and system factors that may pose barriers to expeditious care. **Methods:** A population-based cohort study was performed within the province of Ontario. Using provincial administrative health data, accessed through the Institute for Clinical Evaluative Sciences at the University of Toronto, adult patients with acute tSCI who underwent surgery between 2002 and 2011 were identified using SCI-specific ICD-10 codes. The 2 outcome variables of interest included time to arrival at the site of definitive care and time to decompressive surgery. Bivariate and multivariate statistics were used to quantify the relationship between patient-specific and system-related predictor variables and the outcomes of interest. **Results:** Among 1111 eligible patients, mean times to arrival at the site of definitive care and to surgery were  $8.1 \pm 25.5$  and  $49.4 \pm 65.0$  h, respectively, with 53.3% of patients having undergone surgery before 24 h. While the vast majority of patients (88.4%) presented within 6 h to the site of definitive care, only 34.2% reached surgery within 12 h of arrival. In the multivariate analysis, older age (IRR 1.01, 95% CI 1.01–1.02), increased number of stops at intermediate health care centres (IRR 7.70, 95% CI 7.54–7.86), higher comorbidity index (IRR 1.43, 95% CI 1.14–1.72) and fall-related SCI etiology (IRR 1.16, 95% CI 1.02–1.29) were associated with increased time to arrival at definitive care. For surgery, increased age (OR 1.02, 95% CI 1.01–1.03) and increased number of stops at intermediate health centres (OR 2.48, 95% CI 1.35–4.56) were associated with greater odds of undergoing late surgery as defined by a 24 h cut-off window. **Conclusion:** These results should help to inform policy decisions and allow for the creation of a streamlined path to specialized care for those patients suffering an acute SCI.

**P08: Assessment of surgical treatment strategies for moderate to severe cervical spinal deformity reveals marked variation in approaches, osteotomies and fusion levels.** *Justin S. Smith\**, *Eric Klineberg†*, *Christopher I. Shaffrey\**, *Virginie Lafage‡*, *Frank J. Schwab‡*, *Themistocles Protopsaltis§*, *Justin K. Scheer¶*, *Tamir Ailon\*\**, *Subaraman Ramachandran\**, *Alan Daniels††*, *Gregory Mundis††*, *Munish Gupta†*, *Vedat Deviren§§*, *Christopher P. Ames§§*, *International Spine Study Group†††*. From the \*University of Virginia, Charlottesville, Va.; the †University of California Davis, Davis, Calif.; the ‡Hospital for Special Surgery, New York, N.Y.; the §NYU Hospital for Joint Diseases, New York, N.Y.; the ¶University of California San Diego, San Diego, Calif.; the \*\*University of British Columbia, Vancouver, B.C.; ††Brown University, Providence, R.I.; the ††San Diego Center for Spinal Disorders, La Jolla, Calif.; and the §§University of California San Francisco, San Francisco, Calif.

**Background:** The objective was to assess for consensus on recommended surgical plans for cervical spinal deformity (CSD) treatment. Although previous reports suggest that surgery can

improve the pain and disability associated with CSD, approaches and techniques are not standardized. **Methods:** Eighteen CSD cases were assembled, including a clinical vignette, cervical imaging (x-rays, CT/MRI), and full-length standing x-rays. Fourteen deformity surgeons (10 orthopedic, 4 neurosurgery) were queried regarding the recommended surgical plan. **Results:** There was marked variation in treatment plans across all deformity types. Even for the least complex deformities (moderate mid-cervical apex kyphosis), there was lack of agreement on approach (50% combined anterior-posterior, 25% anterior only, 25% posterior only), number of anterior (range 2-6) and posterior (range 4-16) fusion levels, and types of osteotomies. As the kyphosis apex moved caudally (cervical-thoracic junction/upper thoracic spine) and for cases with chin-on-chest kyphosis, > 80% of surgeons agreed on a posterior only approach and > 70% recommended a pedicle subtraction osteotomy (PSO) or vertebral column resection (VCR), but the range in number of anterior (4-8) and posterior (4-27) fusion levels was exceptionally broad. Cases of cervical/cervical-thoracic scoliosis had the least agreement for approach (48% posterior only, 33% combined anterior-posterior, 17% anterior-posterior-anterior or posterior-anterior-posterior, 2% anterior only) and had broad variation in number of anterior (2-5) and posterior (6-19) fusion levels, and recommended osteotomies (41% PSO/VCR). **Conclusion:** Among a panel of deformity surgeons, there was marked lack of consensus on recommended surgical approach, osteotomies and fusion levels for CSD. Further study is warranted to assess whether specific surgical treatment approaches are associated with better outcomes and to develop improved treatment algorithms for these complex patients.

**P09: Frailty and postoperative outcomes in patients undergoing surgery for degenerative spine disease.** *Raphaële Charest-Morin<sup>†</sup>, John Street<sup>†</sup>, Liam Stobart<sup>†</sup>, Christopher J. Ryerson<sup>†</sup>, Alana Flexman<sup>†</sup>.* From <sup>†</sup>Université Laval, Québec, Que.; and the <sup>†</sup>University of British Columbia, Vancouver, B.C.

**Background:** Frailty is defined as a state of decreased reserve and susceptibility to stressors. The relationship between frailty and outcomes after degenerative spine surgery has not been studied. Objectives were to 1) determine prevalence of frailty in the degenerative spine population; 2) describe patient characteristics associated with frailty; and 3) determine the ability of frailty to predict postoperative outcomes. **Methods:** We analyzed 52 671 patients in the National Surgical Quality Improvement Program who underwent degenerative spine surgery. A modified frailty index (mFI) was used to determine the prevalence and severity of frailty as previously described. The association of frailty with postoperative outcomes was determined using multivariate logistic regression. **Results:** Frailty was present in 2041 patients within the total population (4%), and 8% of patients older than 65 years. Frailty severity rose with increasing age, male sex, African American race, higher BMI, recent weight loss, paraplegia or quadriplegia, ASA score, and preadmission residence in a care facility. Frailty severity was an independent predictor of major complication (OR 1.15 for every 0.10 increase in mFI, 95% CI 1.09-1.22,  $p < 0.0005$ ), and specifically predicted reoperation for postsurgical infection (OR 1.3, 95% CI 1.16-1.46,  $p < 0.0005$ ). Prolonged length of stay and discharge to a new facility were also independently predicted by frailty severity ( $p <$

0.0005). Frailty severity predicted 30-day mortality on unadjusted (OR 2.05, 95% CI 1.69-2.47,  $p < 0.0005$ ) and adjusted analysis (OR 1.44, 95% CI 1.15-1.81,  $p < 0.005$ ). **Conclusion:** Frailty is an important predictor of postoperative outcomes following degenerative spine surgery. Preoperative recognition of frailty may be useful for perioperative optimization, risk stratification and patient counselling.

**P10: Does sarcopenia as assessed by the normalized total psoas area predict early outcomes in elderly patients undergoing elective surgery for degenerative spine disease?** *Raphaële Charest-Morin<sup>†</sup>, John Street<sup>†</sup>, Alana Flexman<sup>†</sup>.* From <sup>†</sup>Université Laval, Québec, Que.; and the <sup>†</sup>University of British Columbia, Vancouver, B.C.

**Background:** Sarcopenia measured by normalized total psoas area (NTPA) has been shown to predict mortality and adverse events (AE) in multiple settings. Its relation with postoperative outcomes after surgery for degenerative spine disease (DSD) has not been defined. Objectives were to 1) describe the distribution and predictors of NTPA, and 2) determine the relationship between NTPA and postoperative outcomes in the elderly DSD population. **Methods:** In total, 302 patients over 65 years old underwent elective surgery for DSD at Vancouver General Hospital between 2009 and 2013, with exclusion of deformity and revision surgery. A total of 102 patients had preoperative imaging to measure TPA at the L3 level. TPA was adjusted for height (NTPA). Surgical invasiveness index (SII) and modified frailty index (mFI) were calculated. Primary outcome was AE collected prospectively with the SAVE database. Hospital LOS and mortality were reported. Predictors of NTPA and its association with AEs was determined using multivariate logistic regression. **Results:** Mean SII was 7.76 (range 0-20). Nineteen (18.6%) patients were frail (mFI > 0.21). Mean NTPA was 674 mm<sup>2</sup>/m<sup>2</sup> (range 293.21- 1636.25) with intra- and interobserver reliability of 0.98 and 0.95. NTPA was predicted by sex and BMI. Forty-two (41.2%) patients had > 1 AE. No in-hospital mortality occurred and mean LOS was 6.6 (range 1-59) days. AEs were predicted by SII on unadjusted (1.77, 95% CI 1.15-2.72,  $p = 0.01$ ) and adjusted analysis (1.81, 95% CI 1.17-2.80,  $p = 0.008$ ). NTPA did not predict AE on both adjusted (1.03, 95% CI 0.9-1.19,  $p = 0.62$ ) and unadjusted analysis (1.06, 95% CI 0.91-1.23,  $p = 0.45$ ). Age, BMI, mFI and ASA were not associated with the primary outcome. **Conclusion:** Sarcopenia assessed by NTPA was reliably estimated in our population. In contrast to other populations, NTPA did not predict complications. Further research is needed to determine the impact of sarcopenia and its optimal measure in the spine population.

**P11: The relationship between pre-existing comorbidities and postinjury adverse events in traumatic spinal cord injury: a prospective Canadian cohort study focusing on potentially modifiable conditions.** *Travis Marion<sup>\*</sup>, Carly Rivers<sup>†</sup>, Dilinuer Kuerban<sup>†</sup>, Christiana Cheng<sup>†</sup>, Vanessa Noonan<sup>†</sup>, Marcel Dvorak<sup>\*</sup>, Charles Fisher<sup>\*</sup>, Brian Kwon<sup>\*</sup>, John Street<sup>†</sup>.* From the <sup>\*</sup>University of British Columbia, Vancouver, B.C.; and the <sup>†</sup>Rick Hansen Institute, Vancouver, B.C.

**Background:** Adverse events (AE) are common throughout the course of care in tSCI patients. AEs disrupt care and negatively impact outcomes. Increased risk of AEs is linked to patient factors

as well as the presence/number of pre-existing comorbidities. Our aim was to establish relationships between pre-existing comorbidities and postinjury AEs, and identify potentially modifiable conditions. **Methods:** Adults with acute tSCI admitted for acute care at a level 1 acute specialized spine centre included in the Rick Hansen SCI Registry (RHSCIR; prospective observational) with AE data collected using the spine adverse events severity (SAVES) system. Patient demographic and injury mechanism/severity data were obtained from RHSCIR. Comorbidity indices as per Charlson and Elixhauser comorbidity indexes were collected from hospital administrative data. Negative binomial regression and multiple logistic regression were used to investigate the impact of patient characteristics on the number of AEs experienced and the 5 most common AEs respectively.  $\chi^2$ /Fisher exact tests were performed to investigate the association between most common AEs and modifiable comorbidities; these associations were re-examined adjusting for age, sex and initial motor score with multiple logistic regression. **Results:** In total, 444 patients were admitted in 2006–2014. Fifty-six percent of patients reported  $\geq 1$  comorbidity, 12.8% had  $\geq 3$  comorbidities. In total, 79.3% experienced at least 1 AE, 38.1% had 3+. Increased age ( $p < 0.01$ ), lower total motor score ( $p < 0.001$ ) and lower education ( $p < 0.01$ ) at admission were non-modifiable independent variables significantly associated with increased AEs. The top 5 AEs were urinary tract infections (UTIs; 42.8%), pneumonia (39.2%), neuropathic pain (31.5%), delirium (18.2%) and pressure ulcers (11.0%). Risk of delirium was increased in those with alcohol/drug withdrawal or psychotic comorbidity; UTI risk increased with alcohol/drug withdrawal; pneumonia risk increased with psychiatric comorbidities. **Conclusion:** AEs are common in tSCI patients. Risk of AEs is associated with nonmodifiable factors. However, opportunity exists for increased AE surveillance in those at risk, and potential reduction of incidence by addressing modifiable risk factors.

**P12: The incidence, severity and impact of adverse events in adult spinal deformity patients: an ambispective cohort analysis.** *Travis Marion, Tamir Ailon, Michael Boyd, Marcel Dvorak, Charles Fisher, Brian Kwon, Scott Paquette, John Street.* From the University of British Columbia, Vancouver, B.C.

**Background:** We sought to determine the true incidence and type of adverse events (AEs) in adult persons consecutively admitted for complex spinal surgery, and to examine their impact on hospital LOS. **Methods:** Consecutively enrolled adult patients treated for adult spinal deformity (ASD) at our institution between 2008 and 2015 were included. A previously published, validated system — the spine adverse events severity system (SAVES) — was used to collect, categorize and grade AE severity. Patients without complete SAVES data were excluded. Demographic data, medical comorbidities, Charlson and Elixhauser comorbidity indexes, intraoperative and postoperative AEs were prospectively collected. We assessed the relationship between patient factors and AEs. Specifically, we analyzed their impact on the total number of AE experiences, and the most common AE types. We also evaluated the correlation between AEs and LOS. **Results:** In total, 132 patients were identified. Mean age was 59.0 years. All patients experienced at least 1 AE. Over half of patients (53.8%) experienced  $\geq 1$  intraoperative AE, and 75.8% experienced  $\geq 1$  postoperative AE. The most common

AEs were UTI (33.3%), delirium (22.7%), postoperative neuropathic pain (19.7%), pneumonia (12.9%) and neurologic deterioration (8.3%). Univariate analysis revealed that patients who experienced  $\geq 1$  postoperative AE were, on average, 6.0 years older than those who did not ( $p < 0.05$ ). Increased age was a significant univariate predictor of delirium ( $p < 0.01$ ) and pneumonia ( $p < 0.05$ ) but was not associated with a higher incidence of any of the other most common AEs. The presence of  $\geq 1$  postoperative AE increased the mean LOS by 13.9 days ( $p < 0.001$ ). **Conclusion:** AEs are common among patients admitted for deformity correction. Increased age is associated with a greater risk of experiencing postoperative AEs, and was found to be a significant risk factor for delirium and pneumonia. LOS was significantly greater in patients who experienced  $\geq 1$  postoperative AE.

**P13: Factors affecting length of stay following 3-column spinal osteotomies in paediatric patients.** *So Kato, Stephen Lewis.* From the Toronto Western Hospital, Toronto, Ont.

**Background:** Little has been understood regarding LOS after 3-column spinal osteotomy for the rigid spinal deformity in the pediatric population. The objective of the present study was to identify factors affecting LOS in these patients. **Methods:** A retrospective review was performed of 38 posterior 3-column osteotomies for pediatric patients. Patients' demographic data, preoperative comorbidities, details of operative procedures, intraoperative complications and postoperative complications were investigated, and LOS was compared among the groups. **Results:** The mean LOS was 12.0 days and the median was 7 days (range 4–85 d). Low body weight ( $< 5$ th percentile), nonambulant patients, pulmonary dysfunction and neuromuscular deformity were associated with longer LOS. Multiple regression analysis revealed that nonambulatory status and neuromuscular deformity were the risk factors for longer LOS (standardized coefficients  $\beta$ : 0.57 and 0.35,  $p < 0.001$  and 0.005, respectively). Those with postoperative respiratory complications (median 21 d v. 7 d,  $p = 0.009$ ) and/or surgical site infection (54 d v. 7 d,  $p = 0.02$ ) stayed longer. Neurological complication did not affect the LOS. **Conclusion:** Nonambulatory status and neuromuscular deformity had longer LOS after 3-column osteotomies. Respiratory complication and surgical site infection were the complications affecting LOS.

**P14: The rate and risk of curve progression following skeletal maturity — Does the story end with curve magnitude?** *Firoz Miyanji\*, Cbris Reilly\*, Suken A. Shab†, David H. Clements‡, Amer F. Samdani§, Sameer Desai\*, Baron S. Lonner¶, Harry L. Shufflebarger\*\*, Randal R. Betz††, Peter Newton‡‡.* From the \*BC Children's Hospital, Vancouver, B.C.; the †Nemours/Alfred I. DuPont Hospital for Children, Wilmington, Del.; the ‡Cooper Bone and Joint Institute, Camden, N.J.; the §Shriner's Hospitals for Children, Philadelphia, Pa.; ¶Mount Sinai Beth Israel, New York, N.Y.; the \*\*Miami Children's Hospital, Miami, Fla.; the ††Institute for Spine & Scoliosis, Lawrenceville, N.J.; and the ‡‡Rady Children's Hospital San Diego, San Diego, Calif.

**Background:** Natural history of adolescent idiopathic scoliosis (AIS)  $\geq 30^\circ$  in skeletally mature patients is poorly defined. Studies reporting rates and risk factors for progression are predominantly of large curves in immature patients. Our aim was to determine

the rate of curve progression in AIS following skeletal maturity, any associated changes in SRS-22 scores, and identify any potential predictors of curve progression. **Methods:** Patients enrolled in a prospective, longitudinal, multicentre nonsurgical AIS database were evaluated. All patients had minimum 2-year follow-up, idiopathic scoliosis  $\geq 30^\circ$ , and were skeletally mature. SRS-22 functional outcome scores and radiographic data were compared at baseline and 2-year follow-up. Patients were divided into 3 groups based on curve size: A =  $30^\circ$ – $39^\circ$ , B =  $40^\circ$ – $49^\circ$ , C =  $\geq 50^\circ$ . Curve progression was defined as any change in curve magnitude. **Results:** There were 80 patients, majority females (93.8%) with a mean age of  $16.5 \pm 0.16$ . Mean BMI was  $21 \pm 0.31$  with 15.1% overweight. Mean major Cobb angle at baseline was  $38.3^\circ \pm 0.88^\circ$ . At 2-year follow-up 46.3% of curves had progressed an average  $3.4^\circ \pm 0.38^\circ$ . Of curves that progressed, patients in group A had the largest mean rate of progression followed by group B. SRS-22 scores on average declined significantly over 2 years in this cohort (4.23 to 4.08,  $p = 0.002$ ). Patients who progressed had on average a more significant decline in SRS outcome scores compared with those who did not ( $p = 0.018$ ,  $p = 0.041$ , respectively), with the most significant change noted in the self-image domain ( $p = 0.03$ ). There was no significant difference in the change in SRS scores over 2 years based on curve size. Univariate analysis did not identify any factors predictive of curve progression in this cohort. **Conclusion:** Skeletally mature patients with AIS  $\geq 30^\circ$  may continue to have a risk of progression at a mean rate of 1.7°/yr and significant decline in SRS-22 outcome scores, in particular pain and self-image, over time. Further longer term follow-up may provide valuable insight into this patient population.

**P15: Integration of a spine assessment clinic prior to surgical consult — a program description.** *Austin Enright, Mike Johnson, Steve Passmore, Mike Goytan.* From the University of Manitoba, Winnipeg, Man.

**Background:** Lengthy surgical consult wait times are an issue for many surgical specialties. Many patients wait 24–36 months for nonacute spine pain consultation. Often patients require only nonoperative treatment. Traditional spine surgery referrals are inefficient for patients and referring, assessing and treating physicians. Hypothesis: We predict that the majority of patients referred to the spine assessment clinic (SAC) will not need spinal surgery upon referral, but instead warrant referral for nonoperative management. **Methods:** For 2 months nonacute spine surgery referrals to 2 spine surgeons were prescreened by 2 advanced practice physiotherapists for appropriateness for 1) spine surgery referral; 2) nonoperative management referral; 3) updated imaging request; and 4) discharge recommendation. **Results:** Average wait time for SAC assessment was under 30 days. There were 71 patients referred to the spine surgeons, who triaged nonacute patients to the SAC. A total of 61 patients (85.9%) attended the clinic for assessment. Of the assessed patients, 12 (19.7%) were referred for surgical consultation, 20 (32.8%) for pain clinic consultation, 24 (55.7%) for in-house physiotherapy, 2 (3.2%) for updated imaging, and 14 (19.7%) were discharged needing no further care. **Conclusion:** The SAC improved the efficiency of clinic utilization of the 2 spine surgeons involved in the program and decreased wait times for patients. Average time to initial spine assessment dropped from 24 months to less than 30 days, a 20-fold improvement. Of the 61 patients, only 19.7% were

appropriate for surgical consultation. Before the SAC integration surgeons were seeing approximately 4 patients for every 1 appropriate surgical consult — an inefficient use of time and resources. The results highlight the number of patients (80.3%) who are presently incorrectly referred for spine surgery consults when nonoperative treatments are more appropriate.

**P16: Improved data capture and quality following implementation of standard operating procedures for a single site in the Canadian Spine Outcomes and Research Network database.** *Eden Daly\*, Neil Manson\*†, Erin Bigney\*, Kate Wagg†, Edward Abraham\*†.* From the ‡Canada East Spine Centre, Horizon Health Network, Saint John, N.B.; and †Dalhousie Medicine New Brunswick, Saint John, N.B.

**Background:** Databases are challenged by high lost-to-follow-up rates leading to compromised validity and poor data quality. This affects the levels of evidence designation for any proposed research using the database. The objective of the current study is to test the effectiveness of new standard operating procedures (SOPs) to reduce patient attrition at a single CSORN centre. **Methods:** A data collection report was generated immediately before and 9 months after SOP implementation examining 12-week, 12-month and 24-month time points. Follow-up rates pre-SOP, post-SOP, and nationally were compared using the nonparametric  $t$  test and Mann–Whitney  $U$  test. Significance was set at  $\alpha > 0.05$ . **Results:** Significant differences were noted for follow-up rates compared nationally, pre-SOP, and post-SOP: 12 months 79%, 75%, 85%, respectively; 24 months 73%, 72%, 81%, respectively ( $p < 0.01$ ). No difference was observed at 12 weeks: 91%, 91%, 93%, respectively ( $p > 0.05$ ). With exclusion of patients outside the capturable time frame at SOP initiation, the SOP proved very robust with significant improvement in follow-up rates: 12 weeks 99% ( $p < 0.05$ ), 12 months 98% ( $p < 0.01$ ), 24 months 95% ( $p < 0.01$ ). Data quality was also improved post-SOP due to increased data accuracy and decreased data points missed. **Conclusion:** Formal introduction of this SOP at the single centre has decreased patient attrition, providing improved data collection at all study time points to 24 months. The new SOP included regular audits and training to ensure data accuracy. Adoption of SOPs at all CSORN sites could potentially improve follow-up rates, and thus quality nationally.

**P17: Survival and clinical outcomes in patients with metastatic epidural spinal cord compression: results from the AOSpine Prospective Multicentre Study of 142 patients.** *Michael Feblings\*, Anick Nater\*, Lindsay Tetreault\*, Branko Kopjar†, Paul Arnold‡, Mark Dekutoski§, Joel Finkelstein¶, Charles Fisher\*\*, John France††, Ziya Gokaslan††, Eric Massicotte\*, Laurence Rhines§§, Peter Rose¶¶, Arjun Sabgal¶¶, James Schuster\*\*\*, Alexander Vaccaro†††.* From the †University of Toronto, Toronto, Ont.; the ‡University of Washington, Seattle, Wash.; the §University of Kansas Medical Center, Kansas City, Kansas; the ¶CORE Institute, Phoenix, Ariz.; the ¶Sunnybrook Health Sciences Centre, Toronto, Ont.; the \*\*University of British Columbia and Vancouver Coastal Health, Vancouver, B.C.; ††West Virginia University, Morgantown, W.Va.; the ††Rhode Island Hospital, Providence, RI; the §§University of Texas MD Anderson Cancer Center, Houston, Texas; the ¶¶Mayo Clinic, Rochester, Minn.; the



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 †††Thomas Jefferson University, Philadelphia, Pa.

**Background:** Although surgery is being increasingly used in patients with metastatic epidural spinal cord compression (MESCC) as a complementary strategy to radiation and chemotherapy, the impact of surgery on quality of life (QoL) is not well established. This study aimed to prospectively evaluate survival, neurologic, functional and QoL outcomes in MESCC patients undergoing operative management. **Methods:** A total of 142 surgically treated patients with a single symptomatic MESCC lesion enrolled in a prospective North American multicentre study were followed for 12 months. Clinical data, such as Brief Pain Inventory (BPI), ASIA Impairment Scale, SF-36, ODI and EQ-5D scores were obtained both pre- and postoperatively. **Results:** The median survival was 7.7 months. The 30-day and 12-month mortality were 9% and 62%, respectively. Six weeks postoperatively, ambulatory status ( $p = 0.02$ ) and bladder control ( $p = 0.03$ ) were significantly improved. Overall, 67.5% of ASIA B, C, or D patients gained at least 1 grade after surgery, 25% remained stable and 7.5% deteriorated. ODI, EQ-5D, BPI scores were significantly improved at each follow-up ( $p < 0.01$ ). SF-36 scores were generally higher after surgery for mental and physical components, and for all domains except energy/fatigue. The incidence of wound complications was 10%, and 2 patients required a second surgery (screw malposition and epidural hematoma). **Conclusion:** Surgical intervention, as a complementary adjunct to radiation and chemotherapy, provides immediate and sustained improvement in pain, neurologic, functional and QoL outcomes with acceptable risks in patients with a focal symptomatic MESCC lesion.

**P18: The clinical utility of the spinal instability neoplastic score (SINS) and its role in surgical management of patients with spinal metastatic disease.** *Ayoub Dakson, Erika Leck, Sean Christie.* From the Queen Elizabeth II Health Sciences Centre, Dalhousie University, Halifax, N.S.

**Background:** Metastatic destruction of integral spinal elements increases the risk of instability, pain and neurologic deficits. The Spinal Instability Neoplastic Score (SINS) is used to assess mechanical instability based on radiographic and clinical factors. We conducted this study to evaluate the clinical utility of SINS in surgical decision-making in spinal metastasis and its association with metastatic epidural spinal cord compression (MESCC). **Methods:** We allocated 285 patients with spinal metastatic disease using our local oncology database, with their disease characteristics identified through a retrospective review. SINS was calculated using good-quality CT imaging studies. The degree of MESCC was assessed using a 0–3 grading system. **Results:** Based on SINS, patients were categorized into stable (34.7%), potentially unstable (52.6%) and unstable (12.6%) groups. There were no cases with esophageal or small cell lung carcinomas associated with unstable SINS, suggesting that some metastatic malignancies may be less prone to spinal instability. Surgical interventions were used in 20.7% of patients, and radiotherapy alone in 69.5%. In the surgical intervention group, there was 69.5% treated with decompression and instrumented fusion, 17% with decompression alone, 8.5% with percutaneous vertebral augmentation and 5% with instrumented arthrodesis. A significantly higher proportion of patients with stable SINS (63.6%) were treated surgically

without instrumentation ( $\chi^2 = 10.6$ ,  $p = 0.005$ ), whereas instrumentation was used in 87.5% of patients with unstable SINS. Instability was associated with metastatic lesions at junctional spinal levels, mechanical pain, deformity, vertebral body collapse  $> 50\%$  and bilateral posterolateral metastatic involvement ( $p < 0.001$ ). Grade 3 MESCC occurred in 65.5% of patients with unstable SINS, whereas 71.4% of patients with stable SINS had grade 0 MESCC ( $\chi^2 = 42.1$ ,  $p < 0.001$ ). **Conclusion:** SINS is associated with higher degrees of MESCC and may play an important role in surgical decision-making, facilitating assessment and recognition of spinal instability in need of urgent appropriate surgical interventions.

**P19: Patterns of spinal metastatic disease and mechanical instability: a retrospective correlation with tumour histology.** *Ayoub Dakson, Erika Leck, Sean Christie.* From the Queen Elizabeth II Health Sciences Centre, Dalhousie University, Halifax, N.S.

**Background:** Spinal metastatic disease develops in 40% of patients with cancer. Clinical manifestations include pain and/or neurologic deficits secondary to spinal instability and/or metastatic compression of the spinal cord/nerve roots. However, the rates of mechanical instability, metastatic epidural cord compression and patterns of spinal metastatic disease in different malignancies are not clear. This study aims to provide epidemiological data concerning spinal instability and patterns of metastatic invasion of the spine based on tumour histology. **Methods:** We allocated 285 patients with spinal metastatic disease using an oncology database, with disease characteristics identified through a retrospective review. The Spinal Instability Neoplastic Score (SINS) was used to describe mechanical instability. SINS was calculated using good-quality computed tomography imaging studies. The Tomita anatomic classification of spinal metastasis was used to group metastasis into either intracompartmental, extra-compartmental or multiple metastasis categories. **Results:** The 3 most common malignancies with spinal metastasis were non-small cell lung (25.3%), breast (17.5%) and prostate (14.4%) carcinomas; the least common pathologies were pancreatic (0.4%), thyroid (1.1%) and uterine (2.8%) cancers. Esophageal cancer was the least likely to be associated with instability, with about 64% of cases being stable. The highest rates of instability scores were observed in breast carcinoma (18% graded as unstable). Renal cell carcinoma was associated with lytic spinal metastases, whereas blastic metastases mostly occurred in prostate carcinoma ( $p < 0.001$ ). While multiple metastases were observed in 68.1% of cases, solitary lesions were intracompartmental (13.3%) or extracompartmental (18.6%). The highest degrees of spinal instability (intermediate and unstable categories) were associated with extra-compartmental metastatic disease ( $p < 0.001$ ). **Conclusion:** This study sheds light on the patterns of spinal metastatic disease and mechanical instability on the basis of tumour histology, using standardized scoring systems. The utilization of such scoring systems allows for a standardized approach toward description and analysis of spinal metastasis facilitating clinical research in this avenue.

**P20: A retrospective analysis of the clinical utility of the Tokunashi scale, and its impact in surgical management of spinal metastatic disease.** *Erika Leck, Ayoub Dakson, Sean Christie.* From the Queen Elizabeth II Health Sciences Centre, Dalhousie University, Halifax, N.S.

**Background:** The evaluation of patients presenting with spinal metastatic disease is often challenging due to the diversity of disease and the variety of factors that influence decision-making. The Tokuhashi scale intends to facilitate this process by incorporating a variety of patient and disease-specific characteristics, in order to assess prognosis and guide intervention decisions. We conducted this study to investigate its clinical utility in surgical decision-making in patients with spinal metastasis. **Methods:** Our local oncology database was used to retrospectively allocate patients with spinal metastasis between 2010 and 2015. The Tokuhashi scale components were determined from a chart review. **Results:** A total of 285 patients with spinal metastatic disease were allocated. The mean age was  $65.3 \pm 11.5$  years, with 53.3% of patients being males. Based on the Tokuhashi scale, there was 68.4% in the nonoperative/radiation group (group 1), 23.9% in the palliative/excisional surgical group (group 2) and 7.7% in the surgical group (group 3). Using the Kaplan–Meier estimate, survival time was significantly different across the 3 groups with means of  $238.3 \pm 408$ ,  $326.2 \pm 293.5$  and  $543.9 \pm 715.5$  days, respectively. A significantly higher proportion of patients (84.6%) in group 1 were treated nonsurgically, compared with 45.5% in group 3 ( $\chi^2 = 19.5$ ,  $p < 0.001$ ). However, there was no correlation between the type of surgical interventions (i.e., instrumented decompression, decompression alone, percutaneous vertebral augmentation and instrumented vertebral augmentation) and the Tokuhashi score. **Conclusion:** The Tokuhashi scale represents a comprehensive prognostic system taking into account a number of disease- and patient-related factors to aid prediction of prognosis and, thus, surgical interventions. This review illustrates the utility of the Tokuhashi scale in predicting survival and guiding subsequent management. However, it does not address the new role of emerging different surgical strategies for the treatment of spinal metastasis and lacks other important information concerning spinal mechanical instability, which influences surgical treatment.

**P21: Length of hospital stay following elective lumbar spine fusion surgery.** *Morsi Khashan\**, *Michael Weber\**, *Greg McIntosh†*, *Joy Barker\**, *Jeff Golan\**. From \*McGill University, Montreal, Que.; and the †Canadian Spine Society, Markdale, Ont.

**Background:** Longer hospital stay following elective spinal procedures is associated with higher costs and may expose patients to nosocomial morbidity. In order to identify predictors for the LOS, we analyzed elective lumbar spine fusion surgery cases using the CSORN. **Methods:** All cases of elective lumbar spine fusion surgeries that consented to CSORN between October 2008 and September 2015 were investigated. We analyzed demographic, preoperative and intraoperative parameters. LOS from surgery to discharge was calculated. The required data were available for 926 cases. Multivariable linear regression was used to model the relationship between the outcomes and the prognostic variables of interest using a backward selection procedure. A data-splitting technique was used to develop and test the multivariable models, whereby a 67% random sample of the full data set was used for model development (Build sample), and the entire data set was used for model validation (Test sample). **Results:** Younger age, principle pathology of degenerative disc disease, fusion of only 1 level, less blood loss, and less operative time were

associated with shorter hospital stay. Surprisingly, smoking also predicted shorter hospital stay. All the parameters resulted in  $p < 0.05$ . **Conclusion:** Our study suggests a number of predictors for shorter hospital stay following lumbar fusion procedures. These results provide helpful evidence for setting hospital recovery expectations and goals. The unexpected effect of smoking on the LOS may be explained by the enhanced incentive of smokers to leave hospitals early after surgery.

**P22: Interspinous process device versus decompression and fusion: further investigation with 2 year follow-up in a degenerative lumbar spondylolisthesis patient population.** *Edward Abraham\*†*, *Kate Wagg\**, *Maxwell Armstrong\*†*, *Erin Bigney\**, *Eden Daly\**, *Neil Manson\*†*. From \*Canada East Spine Centre, Horizon Health Network, Saint John, N.B.; and †Dalhousie Medicine New Brunswick, Saint John, N.B.

**Background:** Our objective was to compare patient- and surgeon-reported outcomes and perioperative data for interspinous process device (IPD) versus decompression fusion (DF) out to 24 months for patients suffering lower extremity symptoms with or without back pain due to degenerative lumbar spondylolisthesis. **Methods:** This is a retrospective review of prospective data. Ninety-six consecutive patients with stable lumbar degenerative spondylolisthesis received DF ( $n = 48$ ) or IPD ( $n = 46$ ). Numeric rating scales (NRS) for back and leg pain and ODI were compared at 24 months. Operating room (OR) time, blood loss, length of hospital stay, rate of surgical revision and patient satisfaction were also compared. Independent  $t$  tests were used to detect between-group differences. The study was powered to detect a 10-point change in ODI. **Results:** Blood loss (IPDm = 60.11, DFm = 506.12,  $t_{93} = -7.723$ ,  $p < 0.001$ ) and OR time (IPDm = 85.35, DFm = 150.75,  $t_{89} = -7.801$ ,  $p < 0.001$ ) were significantly higher, and length of stay in hospital was significantly longer (IPDm = 0.91, DFm = 6.24,  $t_{93} = -7.981$ ,  $p < 0.001$ ) in the DF group. There was no significant difference in amount of subsequent revision surgeries (IPDm = 0.24, DFm = 0.14,  $t_{93} = 1.118$ ,  $p = 0.267$ ). Differences in ODI scores (IPDm = 25.59, DFm = 32.08,  $t_{91} = -1.595$ ,  $p = 0.114$ ), NRS scale for back pain (IPDm = 3.61, DFm = 4.00,  $t_{91} = -0.692$ ,  $p = 0.491$ ) and NRS scale for leg pain (IPDm = 3.34, DFm = 3.45,  $t_{91} = -0.177$ ,  $p = 0.860$ ) were not significant. **Conclusion:** Surgical treatment of stable degenerative lumbar spondylolisthesis with IPD provides equivalent patient-reported outcomes to that of DF with improved perioperative factors. This may translate into improved resource utilization. A larger study powered to detect a small effect is warranted.

**P23: The outcomes following decompression and fusion are compromised when it is preceded by a discectomy or decompression.** *Neil Manson\*†*, *Erin Bigney\**, *Kate Wagg\**, *Eden Daly\**, *Edward Abraham\*†*. From \*Canada East Spine Centre, Horizon Health Network, Saint John, N.B.; and †Dalhousie Medicine New Brunswick, Saint John, N.B.

**Background:** Persistent symptoms after discectomy or decompressions are often managed with revision decompression and fusion despite lack of neurocompression or instability. Etiology of failure may be nerve signalling change (neuropathic pain) or non-physiologic (psychosocial, for example). The study objective is to quantify and compare the outcomes of primary decompression

and fusion to revision decompression and fusion following unsuccessful discectomy or decompression. **Methods:** A retrospective review of prospectively collected data defined 2 cohorts: 91 patients received primary 1- or 2-level decompression and fusion (PF), and 135 received revision 1- or 2-level decompression and fusion following unsuccessful discectomy or decompression (RF). A multivariate analysis of variance was conducted with time of testing and surgical experience as the independent variables and SF-12, numeric rating scale (NRS) back pain and leg pain at 1 year postoperatively as the dependent variables. Significance was set at  $\alpha < 0.05$ . **Results:** Outcomes improved on all measures from baseline to 1 year ( $F_{4,336} = 87.98, p < 0.01$ ) for PF more so than RF ( $F_{4,336} = 10.47, p < 0.01$ ). PF had significantly higher scores for PCS ( $F_{1,339} = 15.57, p < 0.01$ ), MCS ( $F_{1,339} = 26.68, p < 0.01$ ) and NRS back ( $F_{1,339} = 5.34, p = 0.021$ ) and NRS leg ( $F_{1,339} = 17.98, p < 0.01$ ) as compared to RF. A significantly higher ( $p = 0.026$ ) proportion of the RF group (14.8%) failed to show any improvement at 1 year follow-up on 2 or more measures compared with the PF group (7.0%). **Conclusion:** RF did not provide outcomes equivalent to PF. The high percentage of patients in the RF cohort displaying no improvement or deteriorating outcomes indicates it may be necessary to consider alternative treatment strategies when symptoms persist following discectomy or decompression.

**P24: Predictors of response following nonsurgical treatment of low back pain.** *Markian Pabuta*<sup>†</sup>, *Anthony Perruccio*<sup>\*†</sup>, *Elizabeth Badley*<sup>†</sup>, *Raja Rampersaud*<sup>†</sup>. From the <sup>†</sup>University Health Network, Toronto, Ont.; and the <sup>\*</sup>University of Toronto, Toronto, Ont.

**Background:** Current nonspecific LBP treatment demonstrates poor response in many patients. While stratified care based on the STarT Back screening tool (SBST) and level of

disability have been suggested, there remains little knowledge of what factors predict poor response to nonsurgical LBP treatment. We sought to identify factors of response  $\geq 6$  months following nonsurgical LBP treatment. **Methods:** Patients treated through the Inter-professional spine assessment and education clinics (ISAEC) completed a health questionnaire at the initial visit and 6 months following nonsurgical treatment. Patients were classified as responders (good outcome) if their 6-month ODI score improved by  $\geq 10$  units from enrolment. Covariates considered included baseline age, sex, duration of LBP symptoms, LBP pattern, LBP intensity during activity, baseline ODI score and STarT Back chronicity risk. Adjusted log-Poisson regression (with robust variance estimation) was used to identify independent risk factors for poor response. **Results:** In total, 204 patients were included, with mean age 52 (range 18–93) years and 66% female. The risk of poor response decreased by 3% for each unit increase in baseline ODI score, while it increased by 1% for every unit increase in pain intensity score. Females had 50% greater risk of poor outcome than males ( $p = 0.01$ ), those with  $> 12$  months symptom duration had 46% increased risk versus those with  $< 6$  months duration ( $p = 0.03$ ), those with high chronicity risk had 83% increased risk versus those with low chronicity risk ( $p < 0.005$ ), and patients with back-dominant pain aggravated by extension had 55% increased risk of poor response versus those with back-dominant pain aggravated by flexion ( $p < 0.02$ ). **Conclusion:** Independent of baseline disability and chronicity risk, females and those with facetogenic/back dominant symptoms were at increased risk of poor response. These patients represent a growing demographic of the aging population that likely has symptomatic facet osteoarthritis (OA). Further study is needed to identify specific risk factors of poorer response in this group, including potentially confounding systemic OA features.