

Session 4 | Quality/Safety/Value/Complications II Abstracts

Papers are listed in presentation order

Paper #43. The Radiographic, Pulmonary, and Clinical Outcomes of Patients with Severe Rigid Spinal Deformities Treated Via Halo-Pelvic Traction

Yang Junlin, MD, PhD; Wenyuan Sui, MD, PhD

Hypothesis

Patients with severe rigid kyphoscoliosis who underwent preoperative HPT exhibited better radiographic correction of the deformity, and pulmonary function, and required fewer osteotomies compared to the HGT group. Thus, HPT may be useful for severe rigid spinal deformity patients with pulmonary dysfunction.

Design

A retrospective study

Introduction

The severe rigid deformity patients with pulmonary dysfunction could not tolerate complicated corrective surgery. Preoperative traction are used to reduce the curve magnitude and improve the pulmonary function before surgery, including halo-gravity traction (HGT) and halo-pelvic traction (HPT).

Methods

81 cases of severe rigid kyphoscoliosis treated with preoperative traction prior to corrective surgery for spinal deformity between 2016 and 2019 were retrospectively reviewed. Two patient groups were compared, HPT group (N = 30) and HGT group (N = 51). Patient demographics, coronal and sagittal Cobb angles and correction rates, pulmonary function, traction time, osteotomy grade, and postoperative neurological complications were recorded for all cases.

Results

The coronal Cobb angle was corrected from 140.67 ± 2.63 to a mean of $120.17 \pm 2.93^\circ$ in the HGT group, and from 132.32 ± 4.96 to $87.59 \pm 3.01^\circ$ in the HPT group (mean corrections 15.33 ± 1.53 vs. 34.86 ± 3.11 %) ($P = 0.001$). The mean major sagittal curve decreased from 134.28 ± 3.77 to $113.03 \pm 4.57^\circ$ in the HGT group and from 129.60 ± 8.45 to $65.61 \pm 7.86^\circ$ in the HPT group ($P < 0.001$); the mean percentage corrections were 16.50 ± 2.13 and 44.09 ± 9.78 % ($P < 0.001$). A significant difference in the pulmonary function test results was apparent between the two groups; the mean improvements in the FVC% of the HGT and HPT groups were 6.76 ± 1.85 and 15.6 ± 3.47 % ($P = 0.024$). The HPT group tended to exhibit more FEV% improvement than the HGT group, but the difference was not significant (5.15 ± 2.27 vs. 11.76 ± 2.22 %, $P = 0.91$).

Conclusion

Patients with severe rigid kyphoscoliosis who underwent preoperative HPT exhibited better radiographic correction of the deformity, and pulmonary function, and required fewer osteotomies compared to the HGT group. Thus, HPT may be useful for severe rigid spinal deformity patients with pulmonary dysfunction.

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Paper #44. Activity Capacity in Children with Early Onset Scoliosis Compared to Pulmonary Function (Spirometry) and Patient Reported Outcomes

Mark Belio, MA; Malvika Choudhari, BS; Robin C. Johnson, RRT; Di Hu, MS; Stephanie D. Davis, MD; Erik D. Hanson, PhD; Feng-Chang Lin, PhD; James O. Sanders, MD

Hypothesis

Metabolic Equivalents of Task (METs) reflects activity capacity in children with early onset scoliosis.

Design

Cross Sectional Pilot

Introduction

The primary outcome of importance in early onset scoliosis, pulmonary function, is challenging to measure in children. Surrogate measures, including thoracic length and Cobb angle, poorly predict patient outcomes. Activity capacity as determined by metabolic equivalents of task (MET) is a potentially useful alternative. The purpose of this study is to assess MET values for varying intensity activities in children with EOS and its relationships with PFT, scoliosis characteristics, and patient-reported outcomes measures.

Methods

Basal metabolic rate and physical activity MET values were measured using indirect calorimetry. MET values were computed while performing video games representing low (bowling), moderate (boxing), and high intensity (active running) activities, and treadmill walking at low, moderate, and high intensity. MET values were compared to age-matched compendium values for similar tasks. Pulmonary function was assessed using spirometry with % predicted based on arm span. Patient Reported Outcome (EOSQ24) results were obtained for each subject. A linear mixed model was used to assess differences between groups. Pearson correlation coefficients assessed relationships between variables.

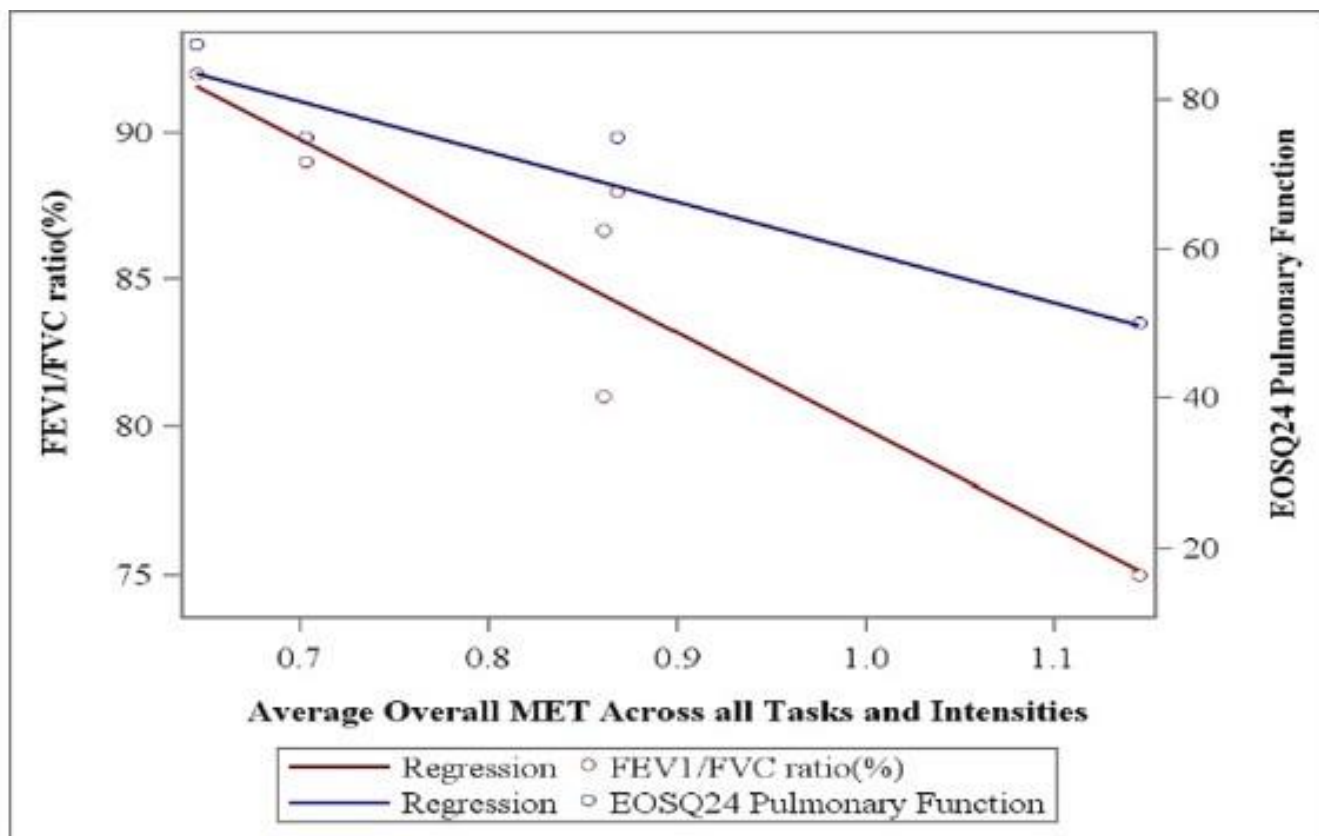
Results

8 children (ages 6-16y, 4M,4F) completed testing. Etiologies were 3 Cong, 3 Syndromic, 2 idiopathic. 5 had severe restriction of FVC and FEV1 <50% predicted. Children with EOS had a 0.6 lower mean MET value compared to published METy values ($p<0.001$). Increased intensity corresponded with increased MET values comparing hard to moderate and easy intensities ($P<0.001$). Average percent predicted MET values across all tasks had a strong negative correlation with FEV1/FVC ($R=-0.927$, $p=0.024$) and EOSQ24 pulmonary function domain across all tasks ($R=-0.992$, $p=0.026$).

Conclusion

This study found the MET values in children with EOS were directionally similar to values in normal children. Children unable to generate higher MET values appear to self-limit their activity. Lower FEV1/FVC corresponded to higher MET values and low EOSQ24 pulmonary function domain scores. Children with pulmonary impairment indicative of obstructive disease require increased energy to perform activities.

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METs compared to PFTs and EOSQ24 PF

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Paper #45. Utility of Preoperative Echocardiogram for Large Curve Scoliosis Patients

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Hypothesis

Screening preoperative echocardiograms in scoliosis patients with $>90^\circ$ curves do not contribute to peri-operative risk or anesthetic management.

Design

Single center retrospective cohort

Introduction

Severe scoliosis can affect thoracic organs, potentially leading to cardiovascular abnormalities. Thus, echocardiograms have been suggested for use in pre-operative screening in patients with significant scoliosis. However, the utility of preoperative heart screenings in patients without known or suspected heart problems isn't well understood. This study aims to find the incidence of cardiac findings in patients with severe scoliosis $>90^\circ$ without cardiac history.

Methods

Chart review was performed from 2018-2023. Inclusion criteria were scoliosis patients with curves $\geq 90^\circ$ and screening echocardiogram performed within six months of spine surgery. Patients with a previous cardiac history, diagnosis associated with cardiac co-morbidities (e.g. connective tissue disease), or primary sagittal plane deformity were excluded. Echocardiogram reports and peri-operative clinical notes from involved services (including orthopedics, cardiology, and anesthesia) were reviewed.

Results

50 patients met inclusion criteria. Mean age at surgery was 14.0 ± 4.9 years old (range 2-33). Mean major Cobb was $108.06 \pm 18.73^\circ$ (range 90° - 160°). 37 (74.0%) patients had a normal echocardiogram report. Six patients (12.0%) had mild dilation of the aortic sinus or root, four (8.0%) had mild valvular regurgitation, one patient had a small atrial septal defect, and one had a trace pericardial effusion. No patient had any changes made to their perioperative plan. One patient was advised to see a cardiologist postoperatively. Eight patients (16%) received vasopressors to raise blood pressure to meet preset goal mean arterial pressure, but only one of these 8 had a positive echocardiogram (mild valvular insufficiency), which wasn't seen as a contributing factor to the use of pressors.

Conclusion

This study suggests that screening echocardiograms for patients without a cardiac history or related symptoms don't contribute to the evaluation of perioperative risk or anesthetic management. Creating clear, evidence-based guidelines for the utilization of perioperative testing, like echocardiograms, can reduce the social, time, and financial burdens on families. Such guidelines are vital for appropriate risk assessment and proper utilization of healthcare resources.

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Table 1. Diagnosis of Patients Among Each Etiology

Neuromuscular (n=27)		Congenital (n=6)		AIS/JIS (n=9)		Syndromic (n=8)	
Quadriplegic Cerebral Palsy	n=16	Thoracic Insufficiency	n=1	Adolescent Idiopathic Scoliosis	n=5	Riley-Day Syndrome	n=1
Alexander's Disease	n=1	Escobar Syndrome	n=2	Juvenile Idiopathic Scoliosis	n=4	Chromosomal Abnormality of Unknown Significance	n=2
Chromosome 2 Microdeletion	n=1	Campomelic Dysplasia	n=1			Bruck Syndrome	n=1
Rett Syndrome	n=1	Congenital Scoliosis Thoracic	n=1			FNLB Deletion	n=1
Babinski-Nagoeffe Syndrome	n=1	Kyphoscoliosis	n=1			Neurofibromatosis	n=2
Spina Bifida	n=1					Trisomy 9	n=1
Pontocerebellar Hypoplasia Type 1B	n=1						
Moyamoya	n=1						
VRK1 Mutation	n=1						
Hemiplegic Cerebral Palsy	n=1						
Central Myopathy	n=1						
Infantile Neuroaxonal Dystrophy	n=1						

Etiology Distribution

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Paper #46. DNA-Based Epigenetic Age is a Better Predictor of Complication than Chronological Age and Frailty

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Hypothesis

DNA-based epigenetic age (EA) better predicts acute complications after ASD surgery than chronological age (CA).

Design

Prospective

Introduction

The prevalence of symptomatic ASD is increasing with an aging population, with surgical complication rates of 37%-71%. Prior studies propose increased CA and frailty as risk factors for complications, but this may be due to differences in EA, suggestive of a patient's underlying biological reserve in response to stress. DNA methylation assays have emerged as the gold-standard for determining EA. We investigated the relationship between EA and complications within 6 weeks after ASD surgery.

Methods

ASD patients provided blood samples on the day of surgery. DNA methylation of PBMCs was analyzed using a genome-wide methylation analysis tool. EA was calculated using the Horvath biological clock (DNAmAge) algorithm. Edmonton Frailty Index (EFI) was collected at the pre-operative visit. EFI, EA, and CA were assessed as risk factors for complications reasonably related to a patient's biology. Parametric and non-parametric analyses were used to assess significance.

Results

30 surgical ASD patients were enrolled. 15 (50%) were revisions. 21 patients (70%) received all-posterior and 9 (30%) underwent anterior-posterior surgery. 7 (23%) received a three-column osteotomy and average levels fused was 11.9 (SD=3.7). Complications were pulmonary emboli (N=2), death (N=1), reoperation for dehiscence (N=1), altered mental status (N=5), and acute kidney injury (N=4). There were no 30-day readmissions. Mean EA and CA were significantly different (71.2 vs 68.4, $p=0.009$). For patients who experienced a post operative complication (N=14, 47%) there was an association with EA>CA (86%) compared to CA>EA (14%, $p = 0.038$). The difference between EA and CA (EA-CA) was greater in patients that had a complication (5.07 vs 0.87, $p=0.029$). There was no association of EFI for frailty between complication groups. Between complication groups, there was no difference in mean CA (67.7 vs 69.0, $p=0.596$), EA (73.0 vs 69.7, $p=0.12$), or EFI (4.3 vs 3.7, $p=0.468$).

Conclusion

Preliminary findings suggest EA>CA has greater association with perioperative complication after ASD surgery than EFI, EA, or CA alone. Further studies with more patients are warranted to investigate epigenetic stressors linked to changes in EA. These patient-specific factors can be used to improve risk-stratification in ASD surgeries.

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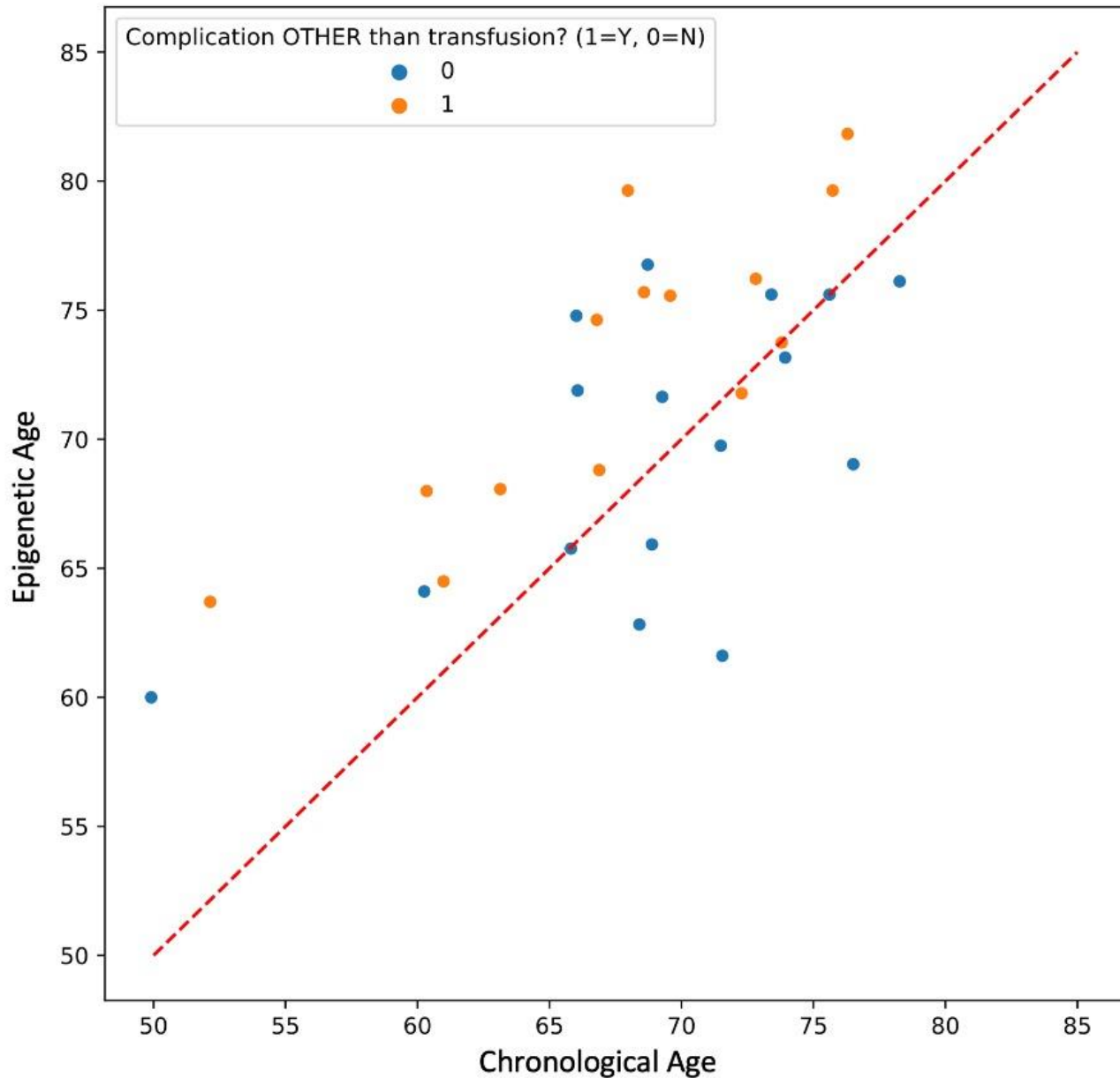


Figure 1: Scatterplot of patients that experienced complications (orange) and no complications (blue). The dotted line represents equal EA (DNAmAge) and CA.

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Paper #47. Optimization is a Moving Target: A Continuous Modifiable Frailty Index Reflecting Optimization Prior to Complex Adult Spinal Deformity (ASD) Intervention

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Hypothesis

Optimization of frailty may improve peri/postoperative outcomes.

Design

Retrospective cohort study of prospectively enrolled database

Introduction

Many surgeons have expanded preoperative surgical planning to not only account for individualized alignment goals but also medical optimization where possible.

Methods

Operative patients with complete BL and 1Y data were analyzed via descriptive statistics and means comparison followed by virtual analysis. Tenets of the modified ASD Frailty Index (m-ASD-FI) that represented modifiable health factors were isolated. Regression analyses was applied to understand the relative value of optimization of each factor.

Results

359 patients met inclusion criteria (mean age: 60.4 ± 15.1 yrs, BMI 27.3 ± 5.6 kg/m², CCI 0.95 ± 1.4 , mASD-FI 7.6 ± 3.1 , EBL 1523.1 ± 1224.4 mL, op time 423.7 ± 139.9 mins, LOS 7.15 ± 5.6 days). 35 patients were considered "optimized" in all categories, while 324 patients were "non-optimized". In factor-by-factor virtual analysis, BMI-optimized patients were less prone to in-hospital complications (OR 0.6, $p=0.043$) or deep wound infection (OR 0.2, $p=0.018$) and more likely to attain 1Y GAP proportionality (OR 2.6, $p=0.004$). CM-optimized patients were less likely to experience a cardiac event (OR 0.2, $p=0.012$) or experience prolonged ICU stay (OR 0.3, $p=0.034$). Osteoporosis-optimized patients were more likely to improve in Schwab modifiers (OR 3.1, $p=0.008$). Depression-optimized patients were significantly less likely to report symptomatic radiographic decompensation (OR 0.4, $p=0.016$). Diabetes-optimized patients were less likely to experience severe radiographic complications, including PJK, requiring intervention (OR 0.13, $p=0.014$). Those optimized in ≥ 3 domains had a significantly decreased likelihood of encountering a spine-related complication (OR 0.9, $p=0.002$) including PJK (OR 0.15, $p=0.026$) and likelihood of attaining alignment at 1 year significantly increased (OR 3.98, $p=0.01$). Amongst those virtually optimized across all domains, fully optimized patients were less likely to experience in-hospital adverse events (OR 0.6, $p=0.039$).

Conclusion

Optimization of frailty is a worthwhile endeavor that may lessen complications and improve retention of alignment. This virtual analysis depicts the possibility of multiplicative effects to optimizing each factor.

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Table 1.

Contributing Factor	OR	p-value
BMI-optimized		
In Hospital AE	0.59 [0.35-0.98]	0.043
Deep Wound Infection	.24 [0.08-0.783]	0.018
Lessened # of Comorbidities		
Prolonged ICU Stay	0.27 [0.08-.90]	0.034
Cardiopulmonary AE	0.23 [0.06-0.73]	0.012
Depression-optimized		
Symptomatic Radiographic Complications	0.41 [0.20-0.85]	0.016
Diabetes-optimized		
Spine-related AE	0.43 [0.21-0.91]	0.03
PJK Requiring Intervention	0.13 [0.03-0.66]	0.014
Osteoporosis-optimized		
Schwab Improvement by 1Y	3.1 [1.4-7.0]	.008
Multiple Domains Optimized (3+)		
Intra-Op AE	0.27 [0.09-0.83]	0.022
PJK	0.16 [0.03-0.80]	0.026
Alignment at 1Y	3.98 [1.4-11.4]	0.01
Fully Optimized (Every Domain)		
In Hospital AE	0.59 [0.35-0.97]	0.039

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Paper #48. The Role of Preoperative *S. Aureus* Colonization in *S. Aureus* Postoperative Infections Following Elective Posterior Spinal Surgery

Aditya Joshi, BS; Rachel S. Bronheim, MD; Amit Jain, MD; Khaled M. Kebaish, MD; Hamid Hassanzadeh, MD

Hypothesis

Preoperative *S. aureus* colonization is associated with increased odds of *S. aureus* postoperative deep incisional, bloodstream, and organ space infections.

Design

Multicenter retrospective cohort.

Introduction

Surgical site infections (SSIs) are a major postoperative complication in spinal surgery that receive extensive prophylaxis with decolonization measures and intrawound antibiotics. The growing literature suggests preoperative *S. aureus* colonization is predictive of superficial *S. aureus* SSIs. However, there is limited discussion on the role of preoperative colonization in postoperative *S. aureus* deep incisional, organ space, and bloodstream infections following elective instrumented spinal surgery.

Methods

This is a retrospective analysis of data collected prospectively in an international, multicenter database of 3,311 patients who underwent multilevel posterior open spinal surgery with instrumentation. Multivariate logistic regression was utilized to determine the independent effect of preoperative *S. aureus* colonization, susceptibility, and colonization region on postoperative infection.

Results

1,168 patients (35.3%) had preoperative *S. aureus* colonization. 68 patients (2.1%) developed a *S. aureus* postoperative infection. Multivariable analysis demonstrated preoperative colonization was associated with increased odds of *S. aureus* superficial surgical site infection (SSI) (OR: 1.65) and bloodstream infection (BSI) (OR: 1.79). Factors associated with increased odds of postoperative infections included preoperative colonization (OR: 1.67), nasal colonization (OR: 1.03) relative to throat colonization, number of vertebrae fused (OR: 1.15), and BMI (OR: 1.06). Prophylactic decolonization was associated with decreased odds of postoperative infection (OR: 0.6). Chlorhexidine wash (OR: 0.4), intranasal mupirocin (OR: 0.13), and a combination of decolonization measures (OR: 0.56) was associated with decreased odds of postoperative infection.

Conclusion

Preoperative *S. aureus* is associated with increased odds of *S. aureus* superficial SSI and BSI. Compared to throat colonization, nasal colonization is associated with increased odds of postoperative infection. Intranasal mupirocin is associated with lower odds of infection relative to a combination of decolonization measures. Further analysis should explore optimal decolonization regimens to implement for at risk patients.

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S. Aureus Infection	# of cases	Univariate (OR 95%CI)	P value	Multivariate (OR 95% CI)	P value
Superficial Surgical Site	24	1.65 (1.19-2.31)	0.003	1.65 (1.17-2.33)	0.004
Deep Incisional	23	1.74 (1.01-2.99)	0.047	1.7 (0.96-3)	0.067
Bloodstream	18	1.77 (0.98-4.03)	0.171	1.79 (1.07-4.18)	0.017
Organ Space	3	0.96 (0.29-3.21)	0.952	1.17 (0.34-3.99)	0.799

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Paper #49. Early Reoperations Do Not Adversely Affect Long Term Pain and Activity Scores in Adult Deformity Patients

Sarthak Mohanty, BS; Fthimnir Hassan, MPH; Nathan J. Lee, MD; Justin K. Scheer, MD; Chun Wai Hung, MD; Steven G. Roth, MD; Erik Lewerenz, BS; Joseph M. Lombardi, MD; Zeeshan M. Sardar, MD; Ronald A. Lehman, MD; Lawrence G. Lenke, MD

Hypothesis

Early complications that are effectively addressed following ASD surgery do not adversely affect two-year outcomes.

Design

Retrospective

Introduction

ASD surgery carries a formidable complication and reoperation rate. The effect of early, resolved reoperations on long-term quality of life is debated, bearing significance for patient counseling.

Methods

ASD patients who underwent spinal fusion at a single institution from 2015-2021 with minimum two years' follow-up were included. Patients without readmissions or reoperations (No Reops) were compared to those requiring early reoperation resolved by 6M post-index procedure (Early Reop) cohort. Outcomes included 2Y PROs, PRO improvements, and MCID attainment. Question 22 from the SRS-22r, assessing likelihood of choosing the same treatment, was separately evaluated. 48 patients were necessary to detect a 0.1-point difference in PRO improvement with 95% power.

Results

238 patients [211(89%) had No Reops; 27(11%) had Early Reop] were included. Early reoperations were associated with PJK/DJK (29.63%, n=8), implant dislodgement (18.52%, n=5), and pedicle/vertebral fracture (14.81%, n=4). Other complications, each at 7.41% (n=2), included painful implants, screw breakage, motor deficits, and spinal cord injury. Between cohorts, there were no differences in demographics, operative characteristics, baseline alignment, and preop PROs. PRO improvement was not significantly different for SRS Activity (0.67 vs 0.54, p=0.392), Pain (1.08 vs 0.88, p=0.291), Appearance (1.35 vs 1.12, p=0.179), Mental Health (0.36 vs 0.33, p=0.840), Satisfaction (1.36 vs 0.93, p=0.098), Total score (0.91 vs 0.74, p=0.152), and ODI (-17 vs -15, p=0.564). MCID achievement was comparable for SRS Activity (59% vs 52%, p=0.536), Pain (74% vs 59%, p=0.115), Appearance (82% vs 78%, p=0.269), Mental Health (36% vs 37%, p>0.999), Satisfaction (82% vs 74%, p=0.149), and ODI (61% vs 70%, p=0.403). SRS total score MCID attainment was greater for No Reops Cohort (82% vs 70%, p=0.048). In addition, a greater proportion of No Reop patients endorsed that they would choose the same operative management (86% vs 70%, p=0.046) if they had to choose again.

Conclusion

Early reoperations within 6 months after ASD surgery that addresses the reason for the revision surgery, does not adversely affect two-year functional and pain outcomes. However, only 70% would choose the same treatment again vs 86% of those who didn't undergo a reoperation.

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	No Reoperations [N=211]	Early Reoperation [N=27]	P Value
Baseline, Preoperative			
SRS Activity	3.06 (0.06)	2.98 (0.15)	0.66
SRS Pain	2.58 (0.06)	2.54 (0.14)	0.8103
SRS Appearance	2.47 (0.05)	2.59 (0.09)	0.4216
SRS Mental Health	3.64 (0.06)	3.77 (0.13)	0.4378
SRS Satisfaction	2.93 (0.07)	3.06 (0.19)	0.5757
SRS Total	2.94 (0.04)	2.98 (0.09)	0.7536
ODI	40.1 (1.27)	43.04 (2.44)	0.4212
Two Years Postop			
SRS Activity	3.73 (0.06)	3.52 (0.14)	0.2188
SRS Pain	3.66 (0.06)	3.42 (0.18)	0.2068
SRS Appearance	3.83 (0.06)	3.71 (0.17)	0.4977
SRS Mental Health	4 (0.06)	4.1 (0.11)	0.5275
SRS Satisfaction	4.29 (0.06)	3.98 (0.17)	0.0802
SRS Total	3.85 (0.05)	3.72 (0.13)	0.3443
ODI	22.98 (1.24)	28.07 (3.13)	0.1618
Two Year - SRS22r Question 22			
Would you have the same management again if you had the same condition?			
"Probably Not" or "Definitely Not"	9 (4.27)	2 (7.41)	0.0456
"Not Sure"	20 (9.48)	6 (22.22)	
"Probably Yes" or "Definitely Yes"	182 (86.26)	19 (70.37)	
Change in PROs			
SRS Activity	0.67 (0.05)	0.54 (0.13)	0.3924
SRS Pain	1.08 (0.06)	0.88 (0.17)	0.291
SRS Appearance	1.35 (0.06)	1.12 (0.15)	0.1794
SRS Mental Health	0.36 (0.05)	0.33 (0.12)	0.8398
SRS Satisfaction	1.36 (0.09)	0.93 (0.28)	0.0978
SRS Total	0.91 (0.04)	0.74 (0.12)	0.1522
ODI	-16.93 (1.15)	-14.96 (3.15)	0.5638
MCID in PROs			
SRS Activity	125 (59.24)	14 (51.85)	0.5355
SRS Pain	156 (73.93)	16 (59.26)	0.1153
SRS Appearance	172 (81.52)	21 (77.78)	0.2688
SRS Mental Health	76 (36.02)	10 (37.04)	>0.9999
SRS Satisfaction	173 (81.99)	20 (74.07)	0.1493
SRS Total	173 (81.99)	19 (70.37)	0.048
ODI	128 (60.66)	19 (70.37)	0.4029

Table 1. Baseline, two-year, changes in patient reported outcomes, and MCID attainment

Legend. Table presents a comparison between patients who experienced no reoperations or readmissions and those who underwent an early reoperation, which was resolved within six months following the index procedure. MCID the SRS22r Question 22 present counts, with the corresponding percentage of the total for each column indicated in parentheses.

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Paper #50. Impact of Durability on Potential to Achieve Cost/Qaly Within the Willingness-To-Pay (WTP) Thresholds for ASD Surgery: It is Impossible Unless We Avoid Reoperations

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Hypothesis

ASD surgeries are unlikely to achieve the WHO WTP threshold of 150K or 250K, within 2-yrs of surgery, regardless of the number of reoperations.

Design

Retrospective Review of a prospective, multicenter registry

Introduction

ASD surgeries are costly and carry high complication rates. Increased scrutiny because of the high-cost is evident. With such a high index cost, the only way ASD surgeries will meet WTP thresholds is sustained durability. Our goal is to examine the impact of reoperations on WTP thresholds.

Methods

ASD patients with >4 level fusion and minimum 2-year follow-up were included. Index and total episode of care (EOC) cost in 2022 dollars were calculated using average itemized direct costs obtained from the administrative hospital records. Cumulative QALY gained were calculated from the change in pre-op to 2-yr post-op SF-6D scores. Durability was defined based on sustaining QALY gain 2-yrs post-op and reaching WTP of 150K or 250K. Cox proportion hazards regression assessed the effect of number of reoperations for 150K-WTP or 250K-WTP in separate models adjusting for patient, surgical, and sagittal deformity characteristics.

Results

Of 1299 patients eligible, 826 (64%) had complete data. The mean age was 61.9±13.4 years, 73% were female, and 93% Caucasians. At 2-yrs, 507 (61%) patients maintained QALY gain with 76 (15%) patients achieving cost/qaly below 150K and 182 (36%) patients below 250K. No significant baseline differences in age, gender, BMI, frailty, SRS-Schwab sagittal deformity, surgical invasiveness, surgical approach, 3-column osteotomies, or LOS. Reoperation rates were lower in patients achieving 150K-WTP (6.6% vs 22.7%; $p=0.001$) and 250K-WTP (7.1% vs 27.7%, $p<0.001$). Multivariate Cox model identified that for every additional reoperation there is 88% (HR: 0.12, 95% CI: 0.09-0.16) and 84% (HR: 0.16, 95% CI: 0.12-0.21) increased hazard of not achieving the WTP threshold of 150K and 250K.

Conclusion

Reoperations are the single most important factor driving the potential to achieve WTP threshold for ASD surgery at 2-yrs. A single reoperation is associated with >80% hazard of not achieving durability at societal WTP 150K or 250K. Efforts to identify and mitigate risk factors associated with reoperations will increase the value of ASD surgery.

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Paper #51. The Safety and Accuracy of Radiation-Free Spinal Navigation Using an Ultrashort, Scoliosis-Specific Bonemri-Protocol Compared to CT

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Hypothesis

MRI-based synthetic-CT spinal navigation is non-inferior to CT for the safety and accuracy of pedicle screw placement at thoracic and lumbar levels.

Design

Investigator-initiated experimental safety study, supported by a Scoliosis Research Society grant.

Introduction

Spinal navigation systems require pre- and/or intra-operative 3D imaging. For all patients, but especially young patients with spinal deformities that require surgical correction, it is important to minimize exposures to ionizing radiation due to an increased risk of developing cancer later in life. We developed a 14-min scoliosis-specific MRI-protocol that provides both T2 MRI and AI-generated synthetic-CT scans. This investigator-initiated and SRS-funded cadaver study aims to test whether the safety and accuracy of MRI-based synthetic-CT spinal navigation is non inferior to CT.

Methods

Of 5 cadavers the total spines were scanned with both thin-slice CT and the scoliosis-specific BoneMRI-protocol. Four spine surgeons independently performed surface matching for navigated placement of 2.5mm k-wires in all pedicles from T3 to L5. Randomization for CT vs synthetic CT, surgeon, and side was performed with a 1:1 ratio. A postoperative CT was acquired, virtual screws with predefined sizes were simulated on the k-wires, and screw position was verified by an independent researcher. Medial breach rate was assessed using the Gertzbein-Robbins classification, while grade A and B were considered satisfactory screw position.

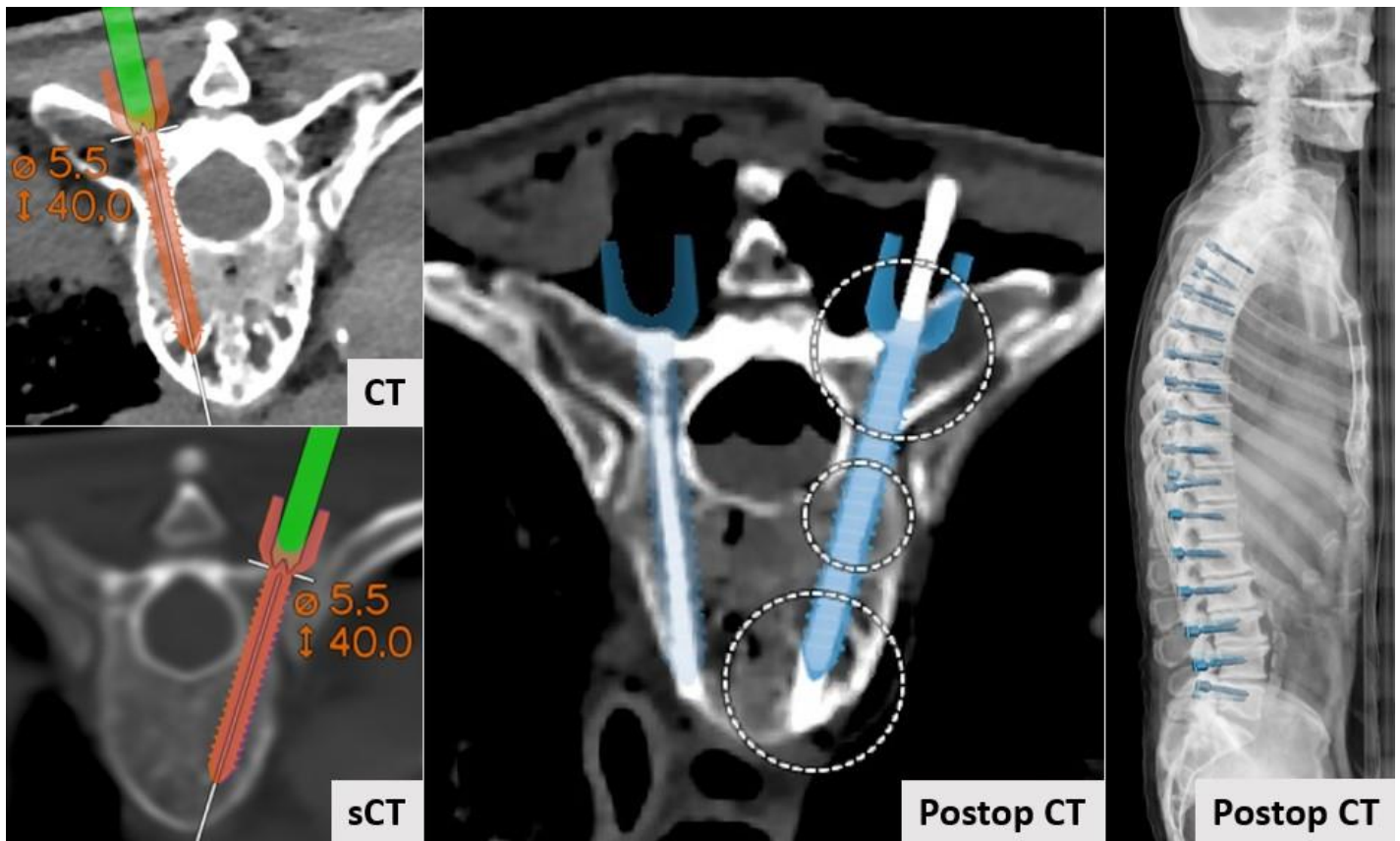
Results

Surface matching was possible on all levels and sides with both modalities. A total of 140 k-wires were inserted. For both modalities, there were no major breaches exceeding the pedicle cortex >2mm. Of the CT-guided screws, 49 were grade A, 21 grade B. For synthetic CT-guided screws, 60 were grade A and 10 grade B.

Conclusion

MRI-based, AI-generated synthetic-CT spinal navigation is feasible and noninferior to conventional CT for insertion of thoracic and lumbar pedicle screws. The use of radiation-free spinal navigation in pediatric spinal deformity surgery is promising and should be further explored.

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Screenshots of intraoperative planning on both CT and sCT. Images of postoperative virtual screws placed over k-wires.

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Paper #52. Neuromuscular Blocking Agent Use in Adolescent Idiopathic Scoliosis Surgery: A Safety Assessment

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Hypothesis

There will be no difference in neuromonitoring alerts or postoperative neurological deficits or complications in patients who receive non-depolarizing neuromuscular blocking agents (nNMBAs) to facilitate exposure compared to those who do not receive nNMBAs during posterior spinal fusion surgery (PSF) in adolescent idiopathic scoliosis (AIS) patients.

Design

Retrospective Cohort

Introduction

Neurological complications are a key concern during deformity correction surgery for patients with AIS. With use of nNMBAs (e.g., rocuronium) during exposure, there is concern that neuromonitoring may be compromised, even with reversal, and may mask neuromonitoring alerts or result in an increase in postoperative neurological complications. We sought to evaluate the safety for use of nNMBAs to facilitate exposure in pediatric PSF as this practice has not been investigated.

Methods

All consecutive AIS patients who underwent PSF at a single academic institution between 2014-2022 were included. Baseline patient comorbidities, utilization of nNMBAs and/or reversal agents, intra-operative blood loss, and surgical complications were recorded for all patients. Patients were categorized into two groups for analysis based on nNMBA utilization (- nNMBA or + nNMBA). Descriptive statistics and Chi-square or Fisher's exact test for categorical variables and Wilcoxon Sign Rank test were utilized to assess differences in outcomes between groups.

Results

327 patients met all selection criteria and were included. Of these, 49 (15%) did not receive any nNMBA (- nNMBA) and 278 (85%) did receive a nNMBA (+ NMBA). Baseline patient characteristics including sex, age, race, BMI, comorbidities, curve magnitude, number of levels fused, and ASA classification were overall similar between the two groups. There were no significant differences in rate of intraoperative neuromonitoring changes ($p=0.78$), postoperative neurological deficits ($p=0.25$), or rate of postoperative complications ($p=0.85$). Clavien-Dindo-Sink grade of complications were statistically similar despite minor differences (Table 1).

Conclusion

Use of nNMBAs to facilitate exposure during PSF for AIS appears safe as it is not associated with any differences in severity of complications or rates of neuromonitoring alerts, postoperative neurological changes, or complications.

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Table 1: Comparison of postoperative complications based on NMBA status.

Characteristics	Overall n=327	- nNMBA n=49	+ nNMBA n=278	P value
Intra-Op Neuromonitoring Changes (%)	27 (8.3%)	3 (6.1%)	24 (8.6%)	0.78
with postop neuro deficit (%)	5 (1.5%)	1 (2.0%)	4 (1.4%)	0.56
without postop neuro deficit (%)	22 (6.7%)	2 (4.1%)	20 (7.2%)	0.55
Post-Op Neuro Changes in Absence of Neuromonitoring Changes (%)	15 (4.6%)	2 (4.1%)	13 (4.7%)	1.00
<u>Postoperative neurological deficit</u>				
None	308 (94.2%)	46 (93.9%)	262 (94.2%)	0.25
Flank Numbness	8 (2.4%)	1 (2.0%)	8 (2.9%)	
LE Numbness	5 (1.5%)	1 (2.0%)	4 (1.4%)	
UE Paresthesias	2 (0.6%)	1 (2.0%)	1 (0.4%)	
Gluteal Numbness	1 (0.3%)	--	1 (0.4%)	
LE Weakness	1 (0.3%)	--	1 (0.4%)	
Transient urinary retention	1 (0.3%)	--	1 (0.4%)	
Radiculopathy	1 (0.3%)	--	1 (0.4%)	
<u>Total Number of Complications</u>				
No Complications (%)	256 (78.3%)	38 (77.6%)	218 (78.4%)	0.59
One Complication (%)	63 (19.3%)	9 (18.4%)	54 (19.4%)	
Two Complications (%)	7 (2.1%)	2 (4.1%)	5 (1.8%)	
Three Complications (%)	1 (0.3%)	--	1 (0.4%)	
Any Complications (%)	71 (21.7%)	11 (22.4%)	60 (21.6%)	0.85
<u>Maximum Clavien-Dindo-Sink Complication Grade**</u>				
No Complications (%)	256 (78.3%)	38 (77.6%)	218 (78.4%)	0.81
Grade One (%)	57 (17.4%)	9 (18.4%)	48 (17.3%)	
Grade Two (%)	7 (2.1%)	2 (4.1%)	5 (1.8%)	
Grade Three (%)	3 (0.9%)	--	3 (1.1%)	
Grade Four (%)	3 (0.9%)	--	3 (1.1%)	
Grade Five (%)	1 (0.3%)	--	1 (0.4%)	

****Note:** Some patients experienced more than 1 complication, so the highest CDS grade complication is reported here.

Table 1: Comparison of postoperative complications based on non-depolarizing NMBA status.

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Paper #53. Intraoperative Neuromonitoring (IONM) Alerts in Cord Level Surgeries for Severe Spinal Deformities – Do Appropriate Corrective Measures Prevent Neurodeficit - Results of Spinal Deformity Intraoperative Monitoring (SDIM) Study

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Hypothesis

Appropriate measures can resolve most (but not all) IONM alerts in surgeries for severe spinal deformities.

Design

Prospective, international multicentric study

Introduction

IONM alerts are commonly encountered in severe spinal deformity surgeries, but prospective multicentric data is lacking regarding resolution measures and the ultimate neurodeficit.

Methods

20 international centers prospectively documented surgical events of patients undergoing spinal deformity correction (Cobb>80°) with MEP, SSEP and EMG monitoring. The standardized data collection form had details of all IONM alerts, including events leading to it and corrective measures taken. Detailed neurological examination was performed at baseline, immediately post-op and at discharge. An alert was defined as a loss of amplitude of >50% in SSEP or MEP from baseline or EMG activity > 10 seconds.

Results

Out of 349 cord level surgeries, alerts occurred 81 times in 57 cases (16.3%) - 24 had multiple alerts. 78 out of 81 alerts (96.3%) had MEP drop (44 unilateral, 34 bilateral) either alone or with SSEP/EMG. 16.6% of PCOs, 15.6% of PSOs and 22.7% of VCRs had alerts. Unilateral MEP drops were most associated with osteotomy (57.9%); for bilateral drops, it was rod capturing (64%). During the osteotomy, 88.4% occurred during decompression on the concavity – screw placement, osteotomy closure or interbody cage placement hardly ever produced alerts. For non-surgical events technical cause was most frequent (9.1%) in unilateral changes, and depth of anaesthesia (26.5%) in bilateral changes. The commonest resolution in unilateral MEP loss was implant removal; for bilateral loss it was rod removal. Out of all 78 MEP alerts, 12.8% got steroids, 11.5% had their correction lessened and 11.5% got ignored. 80.8% alerts recovered fully in ≤ 4.7 minutes. 18.2% of unilateral and 20.6% of bilateral alerts did not recover. 22.8% of those who had and 4.8% of those who did not have an alert had neurodeficit, which occurred in 7.7% of the whole cohort.

Conclusion

16.3% of surgeries had IONM alerts; 96% were MEP drops. Alerts most often occurred during decompression for osteotomies (unilateral) or rod capture (bilateral). With an appropriate response, 80% recovered but 20% did not. A false negative of 5% needs to be resolved in future studies.

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Details of MEP alerts in cord level patients by type of MEP change				
Variable	Type of MEP change			P value
	Unilateral N = 44	Bilateral N = 34	Total N = 78	
Event preceding the alert, n (%) ^a	44	34	78	
Systemic (eg. low blood pressure; anemia)	1 (2.3)	1 (2.9)	2 (2.6)	
Anesthesia	2 (4.5)	9 (26.5)	11 (14.1)	
Technical (eg. malpositioned lead; recording interference)	4 (9.1)	8 (23.5)	12 (15.4)	
Surgical cause	38 (86.4)	25 (73.5)	63 (80.8)	
If surgical cause, please specify, n (%) ^a	38	25	63	
Exposure	0 (0.0)	0 (0.0)	0 (0.0)	
Implant Placement	7 (18.4)	4 (16.0)	11 (17.5)	
Osteotomy/Release	22 (57.9)	4 (16.0)	26 (41.3)	
Correction/Rod Placement	8 (21.1)	16 (64.0)	24 (38.1)	
Traction	2 (5.3)	0 (0.0)	2 (3.2)	
Other	2 (5.3)	3 (12.0)	5 (7.9)	
Implant Placement, n (%)	6	4	10	0.286 ^b
Concave	3 (50.0)	3 (75.0)	6 (60.0)	
Convex	3 (50.0)	0 (0.0)	3 (30.0)	
Neutral	0 (0.0)	1 (25.0)	1 (10.0)	
Osteotomy Type (1), n (%)	22	3	25	0.391 ^b
Posterior column osteotomy (PCO; Type 2)	15 (68.2)	1 (33.3)	16 (64.0)	
Pedicle subtraction osteotomy (PSO; Type 3;4)	2 (9.1)	0 (0.0)	2 (8.0)	
Vertebral column resection (VCR; Type 5;6)	5 (22.7)	2 (66.7)	7 (28.0)	
Osteotomy Type (2), n (%) ^a	22	4	26	
Decompression	17 (77.3)	3 (75.0)	20 (76.9)	
Osteotomy closure	2 (9.1)	1 (25.0)	3 (11.5)	
Interbody placement	1 (4.5)	0 (0.0)	1 (3.8)	
Other	2 (9.1)	0 (0.0)	2 (7.7)	
Response to alert, n (%) ^a	44	34	78	
Elevate BP	16 (36.4)	23 (67.6)	39 (50.0)	
Give blood	9 (20.5)	10 (29.4)	19 (24.4)	
Adjust anesthesia	8 (18.2)	12 (35.3)	20 (25.6)	
Technical	1 (2.3)	3 (8.8)	4 (5.1)	
Rod removal	4 (9.1)	9 (26.5)	13 (16.7)	
Implant removal	8 (18.2)	4 (11.8)	12 (15.4)	
Osteotomy opened	1 (2.3)	0 (0.0)	1 (1.3)	
Osteotomy closed	2 (4.5)	1 (2.9)	3 (3.8)	
Adjust traction	2 (4.5)	3 (8.8)	5 (6.4)	
Steroids	8 (18.2)	2 (5.9)	10 (12.8)	
Decompression	3 (6.8)	3 (8.8)	6 (7.7)	
Lessen Correction	3 (6.8)	6 (17.6)	9 (11.5)	
Complete case	5 (11.4)	4 (11.8)	9 (11.5)	
Case terminated	0 (0.0)	1 (2.9)	1 (1.3)	
Other	18 (40.9)	3 (8.8)	21 (26.9)	

Fig 1

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Paper #54. What Events Are Associated with Intraoperative Neuromonitoring Alerts in Spinal Deformity Surgeries? Results from the Prospective, Multicentre Spinal Deformity Intraoperative Monitoring (SDIM) Study

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Hypothesis

IONM alerts occur more frequently after specific intraoperative maneuvers.

Design

Prospective, multicentre cohorts.

Introduction

Multimodal IONM is the standard of care for spinal deformity surgeries. Our current understanding of the occurrence of IONM alerts during spinal deformity surgeries is limited. The purpose of this study was to determine whether IONM alerts were associated with specific intraoperative maneuvers.

Methods

Patients between aged 10 and 80 with Cobb angle >80° and/or requiring posterior or 3 column osteotomy using multimodal neuromonitoring with EMG, SSEP and MEP were recruited. An alert was defined as SSEP amplitude loss > 50%; MEP amplitude loss > 50% in two of three muscle groups and/or EMG sustained activity for > 10 seconds. Patients were divided into cord level surgery if curve correction was at or above the conus medullaris, and non-cord level if below the conus.

Results

546 patients (349 cord level, 197 non-cord level) were recruited into the study. IONM alerts were recorded in 79 patients (14.5%); 81 alerts occurred in 57 patients (16.3%) at cord level, and 26 alerts occurred in 22 patients (11.2%) at non-cord level. For cord level surgeries, 78/81 alerts had MEP changes (44 unilateral; 34 bilateral MEP changes). The commonest surgical event prior to a unilateral MEP change was an osteotomy/release (57.9%) and correction/rod placement (64%) prior to bilateral MEP change. Unilateral changes most commonly occurred in patients with type 2 osteotomy (68.2%) and type 5 or 6 osteotomy (66.7%) for bilateral changes. IONM alert occurred more frequently during decompression on the concave side (76.5%) in unilateral MEP changes. For non-cord level surgeries, 21/26 alerts had MEP changes (16 unilateral; 5 bilateral). The most frequent event was osteotomy/release prior to unilateral (50%) and bilateral (66.7%) MEP changes. For non-surgical events prior to alert in cord level surgeries, technical was most frequent (9.1%) in unilateral changes; anaesthesia (26.5%) and technical (23.5%) were most frequent in bilateral MEP changes. For non-cord level surgeries, technical (25%) was most frequent in unilateral changes; systemic events (low blood pressure; anaemia (20%); technical (20%)) in bilateral MEP changes.

Conclusion

Specific events are associated with different kinds of IONM alerts.