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Papers are listed in presentation order

Paper #85. Pulmonary Function in Patients with Idiopathic Scoliosis 40 Years After Diagnosis §

Lærke C. Ragborg, MD; Casper Dragsted, MD, PhD; Soren Ohrt-Nissen, MD, PhD; Jann Mortensen, MD, DMSc; Martin Gehrchen, MD, PhD; Benny T. Dahl, Md, PhD, DMSc

Hypothesis

To report the long-term pulmonary function (PF) in patients diagnosed with idiopathic scoliosis (IS) using extended pulmonary function testing (EPFT).

Design

Retrospective follow-up.

Introduction

Pulmonary function in patients with IS has been a topic of concern, with some reports of markedly decreased ventilatory function leading to disability and increased mortality in patients with severe IS. Only limited data is available concerning pulmonary function in adult patients with IS.

Methods

A total of 177 patients seen at our institution from 1972-1983 for a pediatric spinal deformity were included in the study. 91/129 eligible patients with IS (71%) partook in a clinical examination including radiographs, and 79/91 patients (87%) had EPFT performed. The EPFT values included forced vital capacity (FVC), forced expiratory volume in 1 sec (FEV1), FEV1/FVC ratio, vital capacity (VC), total lung capacity (TLC), residual volume (RV), RV/TLC, diffusion capacity of carbon monoxide (DLco), carbon monoxide transfer coefficient (KCO) and alveolar volume (VA). Results were expressed with z-scores derived from height and arm span normative data.

Results

Of 77 included patients, 76 (99%) were females with a mean age of 54.6±2.5 years. The mean follow-up time was 40.8±2.8 years. Forty-four had thoracic main curves, and 33 had TL/L main curves. We found no pulmonary impairment based on z-scores in the total cohort or between groups. Patients with main thoracic curves displayed significantly lower PF on mean absolute values and z-scores on FEV1, FVC, FEV1/FVC ratio, VC, TLC, and DLco compared with main TL/L curves. Patients with thoracic curves had significantly larger Cobb angles at follow-up; 52±17° vs. 40±22° (p-value <0.05) in the TL/L group. We found no linear association between thoracic Cobb angle and degree of pulmonary impairment assessed with DLco, TLC, and FVC. Comparison of pulmonary z-scores based on arm span data, differed significantly on FVC and TLC, with the arm span measurements showing lower z-scores (p-value <0.05).

Conclusion

Using EPFT, no pulmonary impairment could be demonstrated compared to the age-matched population 40 years after a diagnosis of IS. However, patients with thoracic curves had decreased PF compared to TL/L curves. Thus, when treated as current guidelines suggest, patients with IS can expect the same long-term pulmonary function as the general population.

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	Thoracic n=44	Thoracolumbar/Lumbar n=33	Total n=77	p-value
FEV1, L	2.4±0.5	2.7±0.5	2.5 ± 0.5	0.004*
FEV1, Z-score	-0.44±0.35	-0.23±0.30	-0.3 ± 0.3	0.005*
FVC, L	3.2±0.5	3.5±0.7	3.3 ± 0.6	0.021*
FVC, Z-score	-0.47±0.37	-0.29±0.40	-0.4 ± 0.4	0.040*
FEV1/FVC	0.8±0.1	0.8±0.1	0.8 ± 0.1	0.037*
FEV1/FVC, Z-score	-0.53±1.19	0.0±0.90	-0.3 ± 1.1	0.026*
TLC, L	5.1±0.7	5.5±0.8	5.2 ± 0.8	0.039*
TLC, Z-score	-0.42±0.55	-0.23±0.51	-0.3 ± 0.5	0.111
DLco, mmol/min/kPa	6.7±1.1	7.3±1.1	7.0 ± 1.1	0.031*
DLco, Z-score	-0.77±0.81	-0.37±1.00	-0.6 ± 0.9	0.063
KCO, mmol/min/kPa/L	1.5±0.2	1.5±0.2	1.5 ± 0.2	0.870
KCO, Z-score	0.00±1.21	0.03±1.20	0±1.2	0.876
VA, L	4.7±0.6	5.1±0.7	4.8±0.7	0.087
VA, Z-score	-0.80±0.91	-0.45±0.78	-0.6±0.9	0.085

Pulmonary function stratified on main curve

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Paper #86. Halo-Gravity Traction Prior to Growing Rod Insertion: Which Curves Can Benefit? §

Ambika Paulson, MD; Hui Nian, PhD; Jeffrey E. Martus, MD; John T. Smith, MD; Paul D. Sponseller, MD, MBA; John B. Emans, MD; *Michelle C. Welborn, MD*; Pediatric Spine Study Group; Craig R. Louer, MD

Hypothesis

Pre-index Halo-Gravity Traction (HGT) can lower the risk of complications for a subset of severe Early Onset Scoliosis (EOS) patients prior to growing rod (GR) insertion.

Design

Retrospective multicenter cohort

Introduction

HGT has poorly defined benefits in the EOS population with associated time and financial burdens. We sought to investigate the effect of pre-operative HGT treatment (vs. no HGT) on complications in EOS patients receiving GR surgery to identify curve severities where HGT offers benefit.

Methods

A multicenter pediatric spine registry was queried for EOS patients who have undergone TGR, VEPTR, or MCGR insertion with >2-year follow-up. Patients were grouped into HGT and “non-HGT” (nHGT) cohorts based on presence of HGT treatment prior to index GR surgery. Complications related to the device or procedure and requiring unplanned surgical treatment were the primary outcome. A multivariable regression model for 2-year complications included age, race, etiology, ambulatory status, weight, GR type, rod number, and pelvis attachment. For modeling, normal kyphosis values were set to 0, then re-adjusted for reporting results.

Results

1938 patients were included, of which 187 (9.6%) were treated with HGT. In unadjusted analysis, HGT had less 2-year complications (12% vs. 19%, p=0.037) than nHGT group. In the multivariate model, both baseline coronal (p=0.012) and sagittal (p=0.003) deformity significantly affected odds of complication with sagittal deformity having the strongest effect (Figure 1). With normal sagittal alignment, no severity of coronal deformity demonstrated benefit of HGT. However, when kyphosis >80°, scoliosis of 70°-90° treated with HGT demonstrated lower odds of complications (all p<0.05), with that range expanding at higher kyphosis severity.

Conclusion

Treatment with HGT prior to GR results in reduced odds of complications relative to non-HGT patients depending on severity of coronal and sagittal deformity. Patient-specific complication odds ratios will be of value for patients and surgeons weighing the burdens associated with HGT treatment.

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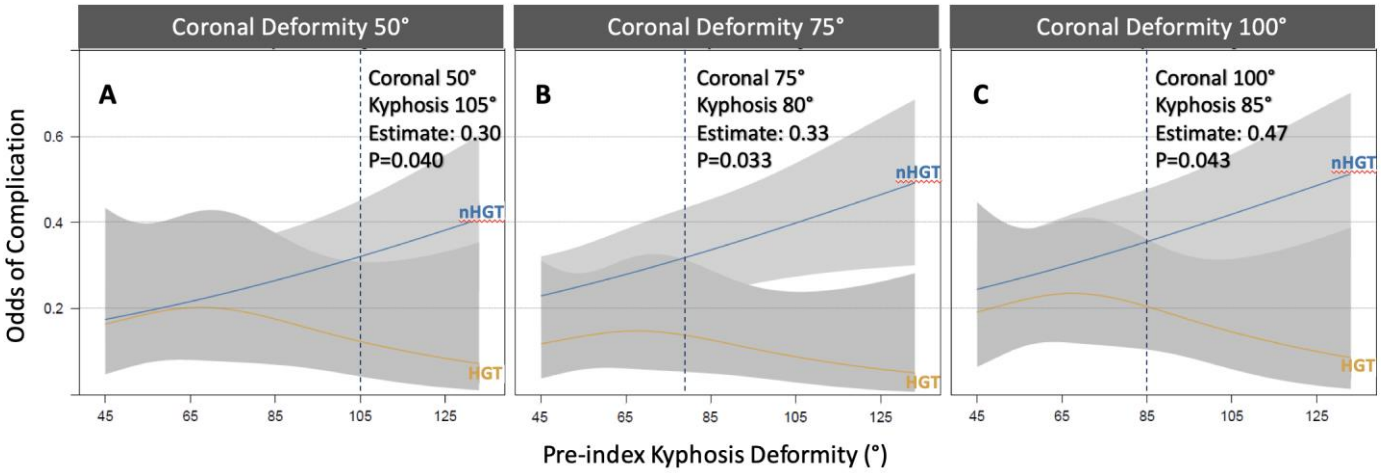

Example plots with defined coronal deformity demonstrate a difference in complication odds between HGT and nHGT treatments as kyphosis increases. Threshold where statistical difference is reached is highlighted in each graph.

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Paper #87. Pneumonia Induced Mortality and Risk of Pneumonia in Children with Cerebral Palsy with Scoliosis Treated with and Without Surgery §

Matti Ahonen, MD, PhD; Ira Jeglinsky-Kankainen, PhD; Mika Gissler, PhD; Ilkka J. Helenius, MD, PhD

Hypothesis
We hypothesized that scoliosis surgery reduces incidence of pneumonia and pneumonia related mortality in individuals with CP and scoliosis.

Design
Retrospective national registry investigation.

Introduction
Scoliosis is common in children with cerebral palsy (CP). Scoliosis surgery in children with CP increases HRQoL and reduces caregiver burden, but effects of scoliosis surgery on incidence of pneumonia and pneumonia-related mortality remain obscure. The purpose of this study was to compare incidence of pneumonias and pneumonia-related mortality in scoliotic children with CP with and without spinal deformity surgery.

Methods
We identified 4571 children who had been diagnosed with CP between 1996 and 2022 from national registries, of these 474 children with CP had been diagnosed with scoliosis. Two hundred and thirty-six had not been operated and 238 were operated for scoliosis during the follow-up median 17.8 (IQR 11.7-25.7) and 23.0 (IQR 18.4-28.2) years, respectively. Associated co-morbidities, incidence of pneumonias and pneumonia-related mortality were analyzed between groups. To compare groups and assess the impact of surgery, we established the index timepoints as the age at the diagnosis of scoliosis (12.1 years) for the non-surgical group and the age at surgery (12.9 years) for the surgical group.

Results
Children with CP and scoliosis with non-surgical and surgical treatment were diagnosed with scoliosis at the age of 12.1 and 12.5 years, respectively. Both groups had similar co-morbidities. During follow-up 47.9% in non-surgical and 54.2% in surgical group had been diagnosed with pneumonia. However, there was difference in cumulative incidence of pneumonia between groups before and after index timepoint. In non-surgically treated group, there was 192.8 hospitalizations for pneumonia before and 203.9 after the index timepoint for 1000 follow-up years ($p=0.334$). In surgically treated group there was 175.5 hospitalizations for pneumonia before and 121.5 after the surgery for 1000 follow-up years ($p<0.001$). During the follow-up pneumonia related mortality was higher in the non-surgically treated group than in the surgically treated group (n=22/236, 9.3% vs. n=8/238, 3.3%, $p=0.008$) (Fig. 1.).

Conclusion
These results indicate that surgical treatment of scoliosis in children with CP reduces incidence of pneumonia and pneumonia-related mortality.

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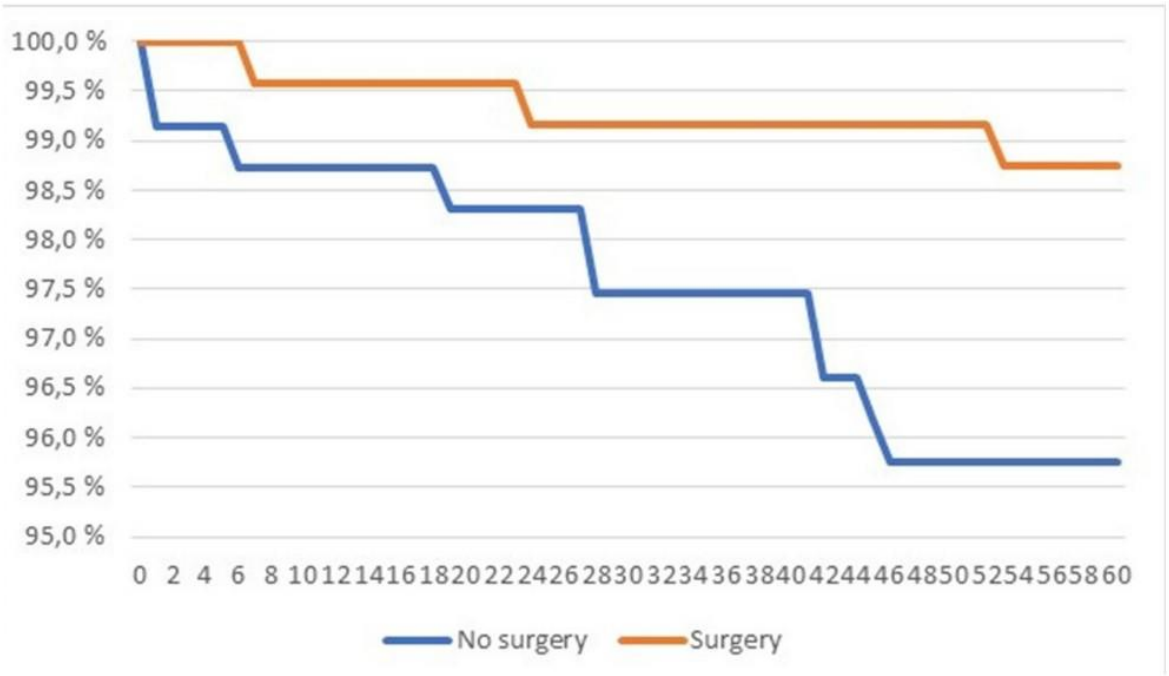

Fig.1 Observed mortality

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Paper #88. Long-Term Outcomes of Operative Versus Nonoperative Treatment for Adult Symptomatic Lumbar Scoliosis (ASLS): Durability of Treatment Effects and Impact of Related Serious Adverse Events Through 8-Year Follow-Up § ‡

Justin S. Smith, MD, PhD; Michael P. Kelly, MD; Elizabeth L. Yanik, PhD; Christine Baldus, RN; Vy Pham, MD, MPH; David Ben-Israel, MD; Jon D. Lurie, MD, MS; Charles C. Edwards, MD; Steven D. Glassman, MD; Lawrence G. Lenke, MD; Oheneba Boachie-Adjei, MD; Jacob M. Buchowski, MD; Leah Y. Carreon, MD; Charles H. Crawford III, MD; Stephen J. Lewis, MD, FRCS(C); Tyler Koski, MD; Stefan Parent, MD, PhD; Virginie Lafage, PhD; Munish C. Gupta, MD; Han Jo Kim, MD; Christopher P. Ames, MD; Shay Bess, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Keith H. Bridwell, MD

Hypothesis
Treatment effects (TEs) favoring operative (op) over nonoperative (nonop) treatment for ASLS will deteriorate over 8-yr follow-up.

Design
Prospective multicenter study

Introduction
Long-term follow-up studies of op and nonop ASLS treatments are needed to assess benefits and durability.

Methods
The ASLS study is an NIH (2010-2017) and SRS (2017-present) sponsored multicenter prospective study to assess op vs nonop ASLS treatment, with randomized and observational treatment arms. Patients were 40-80 yrs with ASLS (Cobb >30° and ODI >20 or SRS-22 subscore <4.0 in pain, function and/or self-image). Op and nonop patients were compared using as-treated analysis, and the impact of related serious adverse events (SAEs) was assessed.

Results
The 286 ASLS patients enrolled (104 nonop, 182 op) had follow-up rates at 2, 5, and 8 yrs of 90% (256), 70% (199), and 72% (205), respectively. At 2 yrs, compared with nonop, op patients had greater improvement in SRS-22 (mean difference=0.57) and ODI (mean difference=-12.98) ($p<0.001$, Figure), with treatment effects (TEs) exceeding minimal detectable measurement difference (MDMD) for SRS-22 (0.4) and ODI (7). TEs at 5 yrs (SRS-22=0.58, ODI=-11.25, $p<0.0001$) and 8 yrs (SRS-22=0.74, ODI=-14.29, $p<0.0001$ for both) remained as favorable as 2-yr TEs. The SAE incidence rates for op patients at 2, 2-5, and 8 yrs were 20.5, 9.4, and 8.5 per 100 person-yrs, respectively. The majority of SAEs were revision surgeries. At the 2, 5, and 8 yr timepoints, there were 31, 34, and 23 revisions in 27, 32, and 20 patients, respectively. At 8 yrs, op patients with 1 SAE still had significant improvement, with TEs that exceeded MDMD (SRS-22=0.62, ODI=-9.5, $p<0.0001$, Figure). The 22 op patients with 2+ SAEs at 8 yrs had significant improvement of both SRS-22 (TE=0.49, $p=0.0002$) and ODI (TE=-6.0, $p=0.0381$) compared to nonop treatment, but only the SRS-22 TE exceeded MDMD.

Conclusion
Op treatment for ASLS provided significantly greater clinical improvement than nonop treatment at 2, 5 and 8 yr follow-up, with no deterioration. Patients in the op cohort with a related SAE maintained greater improvement than patients in the nonop cohort. These findings demonstrate long-term durability of surgical treatment for ASLS and may prove useful for patient counseling.

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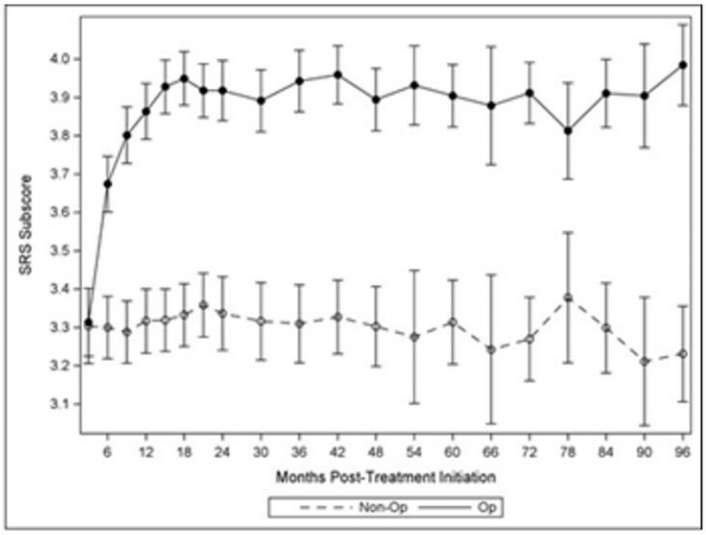

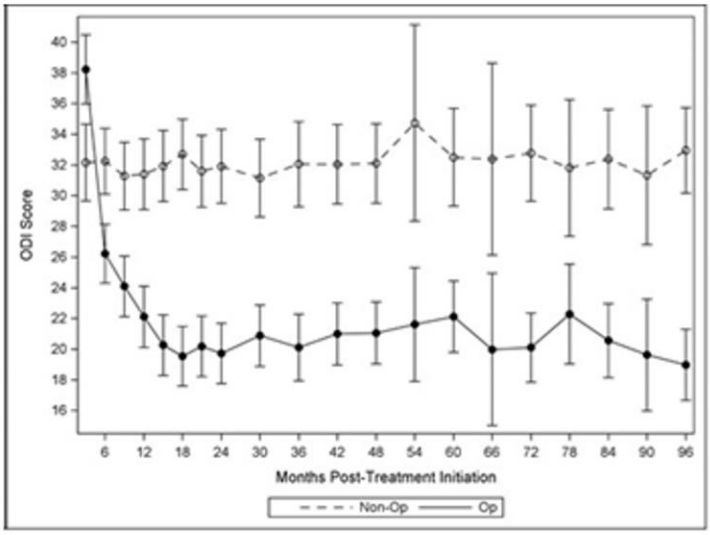

Comparison of primary outcomes on operatively treated adult symptomatic lumbar scoliosis patients with and without a related serious adverse event to non-operatively treated patients.*

	As Treated, Combined (Randomized + Observational) Cohort					
	2 Years		5 Years		8 Years	
	Mean Difference (95% CI)	P value	Mean Difference (95% CI)	P value	Mean Difference (95% CI)	P value
ODI						
Non-operative	Referent		Referent		Referent	
Operative with no SAE	-13.6 (-16.8, -10.4)	<0.0001	-11.4 (-15.6, -7.2)	<0.0001	-16.7 (-20.5, -12.9)	<0.0001
Operative with 1 SAE	-11.8 (-16.5, -7.2)	<0.0001	-10.8 (-15.9, -5.8)	<0.0001	-9.5 (-14.2, -4.7)	<0.0001
Operative with 2+ SAE	-0.3 (-6.5, 6.0)	0.9386	-3.9 (-10.9, 3.1)	0.2754	-6.0 (-11.6, -0.4)	0.0381
SRS subscore						
Non-operative	Referent		Referent		Referent	
Operative with no SAE	0.61 (0.48, 0.74)	<0.0001	0.63 (0.47, 0.79)	<0.0001	0.86 (0.69, 1.03)	<0.0001
Operative with 1 SAE	0.43 (0.24, 0.62)	<0.0001	0.56 (0.38, 0.75)	<0.0001	0.62 (0.41, 0.84)	<0.0001
Operative with 2+ SAE	0.18 (-0.08, 0.43)	0.1779	0.30 (0.04, 0.56)	0.0220	0.49 (0.23, 0.75)	0.0002

*CI = confidence interval; SRS = Scoliosis Research Society; SAE = serious adverse event (only those that are classified as Possibly/Probably/Definitely related); ODI = Oswestry Disability Index

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Paper #89: Assessment of Modern Iatrogenic Flatback Syndrome: Nearly 70% of Short Lumbar Fusions Had Undercorrection of L4-S1 Lordosis §

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Hypothesis
Iatrogenic adult spinal deformity (ASD) is commonly secondary to prior poorly aligned degenerative lumbar spinal fusion.

Design
Retrospective review of prospectively collected data.

Introduction
Revision spinal procedures in deformity patients are costly and invasive. However, the prevalence, modes of failure, and extent of deformity of iatrogenic ASD is unknown.

Methods
ASD patients with (IATROGENIC) and without (PRIMARY) prior spine surgery were included. IATROGENIC patients were prior short (L1-iliium) (IATROGENIC DEGEN) and long fusion (IATROGENIC DEFORMITY) constructs. DEGEN patients were further stratified into common modes of failure: implant, junctional, malalignment, and neurologic. Comparative analyses were performed on baseline demographics, spinopelvic alignment, offset from published segmental lordosis goals, patient-reported outcome measures (PROMs), and surgical procedures.

Results
Among 785 patients, 430 (55%) were PRIMARY, 181 (23%) were IATROGENIC DEFORMITY, and 174 (22%) were IATROGENIC DEGEN. DEGEN modes of failure included 27% implant, 40% junctional, 73% malalignment, and 28% neurologic. DEGEN patients were older (PRIMARY=60.6 vs DEGEN=66.3 years) and frailer (2.8 vs 4.4), and had worse baseline deformity (PT, PI-LL, SVA, L4-S1) and PROMs (NRS Back Pain, ODI, SRS-12 Total) compared to primary patients (all $p<0.001$). Segmental lordosis analysis revealed that 98/131 (75%) of SRS-Schwab type N patients were undercorrected, and only 12% were matched to L4-S1 goal (35-40 degrees). Likewise, 67/93 (72%) patients with L4-S1 spanning constructs, 19/21 (91%) patients with L1-L4 spanning constructs, and 10/11 (91%) patients with L1-S1/ilium spanning construct were undercorrected (Figure). DEGEN patients more often underwent 3-column osteotomies (12% vs 30%, $p<0.001$) and decompression (50% vs 62%, $p=0.021$), and had a higher Surgical Invasiveness Score (78.3 vs 87.8, $p=0.006$).

Conclusion
Nearly half of ASD surgeries were revision spinal fusions. Revisions were predominantly associated with sagittal malalignment with 72-91% being undercorrected to segmental lordosis goals, often at L4-S1. Revision patients underwent more invasive procedures, such as 3-column osteotomy. Further initiatives to optimize alignment are needed to avoid costly and invasive deformity corrections.

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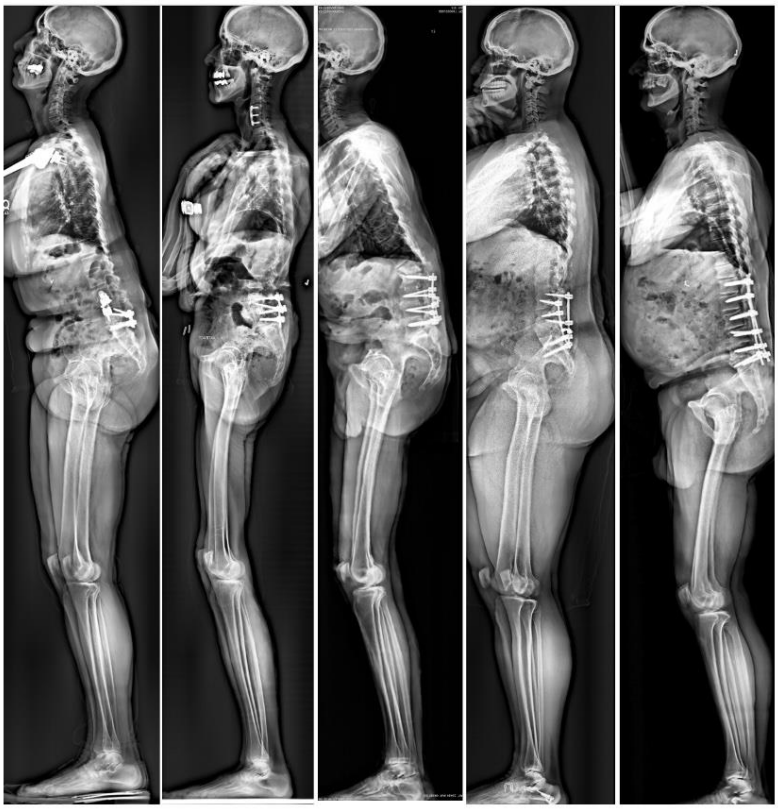

	PRIMARY (N=430)	REVISED (N=174)	P value
Spinopelvic Parameters			
PT (°)	23.0 (10.8)	28.0 (9.1)	**<0.001**
PI (°)	52.9 (12.6)	57.9 (13.9)	**<0.001**
TK (°)	-35.5 (21.3)	-30.1 (17.6)	**0.003**
LL (°) L1-L4 (°) L4-S1 (°)	39.4 (24.0) 3.2 (20.1) 36.2 (15.2)	28.3 (21.1) 1.6 (18.7) 26.7 (13.0)	**<0.001** 0.556 **<0.001**
PI-LL (°)	13.5 (22.0)	29.6 (18.5)	**<0.001**
SVA (mm)	50.8 (61.5)	106.3 (66.8)	**<0.001**
T1SPi (°)	-1.9 (5.9)	3.3 (6.7)	**<0.001**
Patient-Reported Outcome Measures			
NRS Back Pain	6.9 (2.4)	7.6 (2.0)	**<0.001**
ODI	41.0 (18.1)	50.5 (15.0)	**<0.001**
SRS-22 Total	2.9 (0.6)	2.7 (0.5)	**<0.001**

Figure 1. Preoperative imaging (left) and outcomes (right) for patients undergoing fusion with and without previous lumbosacral fusion.
Abbreviations: PT = Pelvic Tilt, PI = Pelvic Incidence, TK = Thoracic Kyphosis, LL = Lumbar Lordosis, L1-L4 = L1-L4 Lordosis, L4-S1 = L4-S1 Lordosis, PI-LL = Pelvic Incidence minus Lumbar Lordosis, SVA = Sagittal Vertical Axis, T1SPi = T1 SpinoPelvic Inclination, NRS = Numerical Rating Scale, ODI = Oswestry Disability Index, SRS-22 Total = Scoliosis Research Society 22-Item Total.

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Paper #90. Exploring the Indications, Failures, and Treatment of Complications After a C2 to Pelvis Fusion §

Nathan J. Lee, MD; Fthimnir Hassan, MPH; Ted Shi, BS; Anastasia Ferraro, BS; Chun Wai Hung, MD; Steven G. Roth, MD; Justin K. Scheer, MD; Zeeshan M. Sardar, MD; Joseph M. Lombardi, MD; Lawrence G. Lenke, MD; Ronald A. Lehman, MD

Hypothesis
Complications are high and often involve C2 or above

Design
Retrospective Single Center

Introduction
Fusions from the cervical spine to pelvis are relatively uncommon procedures. As a result, their indications and complications are not well-characterized in the current literature. In the largest series on C2 to pelvis fusions, we seek to better elucidate the C2-related complications and treatments.

Methods
A single center series of patients who underwent a posterior spinal instrumented fusion from C2 to sacrum (2016-2023), both primary and revision cases, were included. Patient demographics, medical history, diagnosis, operative procedures, and complications were analyzed.

Results
A total of 37 patients underwent posterior spinal instrumented fusion from C2 to Ilium. The mean follow up was 1.9 years, mean age 56±19 years, 57% were female, and 38% had osteoporosis or osteopenia. Most patients had a prior fusion surgery 81% (N=30), which commonly included upper thoracic to sacrum (N=15) and cervical-thoracic (N=5) fusions. Most common reasons for C2 to Ilium constructs included proximal junctional kyphosis/failure (N=12), chin-on-chest deformity (N=5), and pseudarthrosis (N=5). The surgical complication rate was 46% (17/37), the revision surgery rate was 38% (14/37), and 3 patients required multiple revision surgeries after the C2 to pelvis construct. Reoperations commonly addressed C2-related fractures (N=6), wound complications (N=5), and pseudarthrosis unrelated to C2 (N=4). For those with C2 issues, surgery included either extension of fusion to Occiput (N=2) and C1 (N=4) or revision C2 (N=2). Four patients with radiographic C2 issues (i.e. partial screw pull-out) were treated non-operatively in a hard collar after appearing stable on repeat imaging.

Conclusion
This is the largest series of C2-ilium reconstructions with a mean follow-up of 2 years. The most common indication for surgery to C2 was PJK/F, followed by chin-on-chest deformity and pseudarthrosis. The surgical complication rate was 46%, and the revision rate was 38%. The most common reason for revision surgery was C2 related fractures and screw loosening, with 43% being extended to C1 or the occiput. Long constructs from C2-ilium carry a high complication rate and require frequent follow-up to assess for long term issues.

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Patient #	Complications Per Patient	Related to C2 or Above?	Revision Surgery	Days After C2 to Pelvis Surgery
1	Instrumentation Failure/Pseudarthrosis	No	Revision Thoracic to Sacrum Fusion	1483
2	Instrumentation Failure/Pseudarthrosis	No	Revision Thoracic to Sacrum Fusion	1001
3	Instrumentation Failure/Pseudarthrosis	No	Revision Thoracic to Sacrum Fusion	343
4	Instrumentation Failure/Pseudarthrosis	No	Revision Thoracic to Sacrum Fusion + L3 PSO	882
5	Wound Complication	No	Irrigation & Debridement	14
6	Wound Complication	No	Irrigation & Debridement	464
7	Wound Complication	No	Irrigation & Debridement	57
8	Sagittal Imbalance	No	Revision Thoracic to Sacrum Fusion + L3 PSO	397
9	Falls due to Parkinsons. Complete Screw pullout C2-4 + Dens Fracture	Yes	ACDF C2-T1 + PCF C1-T4	298
10	Wound Complication	No	Irrigation & Debridement	31
	Dropped head syndrome w/o fall/trauma, Complete pullout screws b/l C2-5	Yes	ROI at C2-T9 with revision PSIF C1-T8	127
	Failure of C1-2 screws. C1 screw migrated cephalad into OC joint as well as a loose C3 screw	Yes	Revision fusion C1-T3	246
11	Wound Complication	No	Irrigation & Debridement	28
	Dens fracture after Fall	Yes	Revision with fusion C1-2	526
12	Dens fracture after Fall	Yes	Occiput to T4	210
13	Left C2 Pars Screw pullout without Fall	Yes	Revision C2-3	329
	Instrumentation Failure/Pseudarthrosis	Yes	ACDF C2-3 and C7-T1, Revision PSIF C2-T1	391
14	Dens fracture after Fall	Yes	Occiput to T4	28

Fig. 1

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Paper #91. Vitamin A Deficiency Induces Congenital Vertebral Malformation Via Retinoic Acid Signaling Mediated Sclerotome Dysplasia †

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Hypothesis
Vitamin A deficiency induces congenital vertebral malformation via inhibiting sclerotome differentiation. The inhibition of sclerotome differentiation is related to retinoic acid signaling pathway.

Design
Basic research

Introduction
Congenital vertebral malformations (CVMs) is a result of abnormal sclerotome development. Previous study has indicated that vitamin A deficiency (VAD) induced CVMs in rats. However, the phenotype observed through X-ray was indistinct and the mechanism was still unclear. In this study, 3D model of vertebral malformation was constructed and further pathogenesis of VAD induced CVMs was revealed.

Methods
Female rats were randomized into VAD group and control (CON) group. Female rats in VAD group were fed with vitamin A deficient AIN-93G diet for at least 2 weeks, while female rats in CON group were fed with vitamin A sufficient AIN-93G diet. After mating, embryos from gestational day (GD) 10.5 and GD12.5 were collected, and 2 weeks neonatal rats were euthanized in both groups. Micro-CT and X-ray were utilized to construct 3D model of vertebral malformation from 2 weeks neonatal rats. Whole mount in situ hybridization (WMISH) was applied to visualize the expression pattern of Pax1 and RALDH2 in GD10.5 and GD12.5 embryos. Combining laser captured microdissection, RNA-seq of sclerotome was proceed in GD12.5 embryo.

Results
Micro-CT and X-ray results showed the incidence of CVMs in neonatal rat was 32.65% (16/49) in VAD group and 0% (0/41) in CON group, all CVMs were butterfly vertebrae which was classified as failure of vertebral formation. In VAD group, WMISH result showed Pax1 was down-regulated in sclerotome at GD10.5 and RALDH2 was down-regulated in somite at GD10.5, while the expression pattern of Pax1 did not differ between two groups at GD12.5. RNA-seq result showed 1507 mRNAs were down-regulated and 596 mRNAs were up-regulated. Kyoto Encyclopedia of Genes and Genomes enrichment analysis showed down-regulated mRNAs were enriched to osteoclast differentiation.

Conclusion
VAD induces failure of vertebral formation via inhibition of sclerotome differentiation which is mediated by retinoic acid signaling pathway. Osteoclast differentiation may be a potential pathway associated with the pathogenesis of CVMs.

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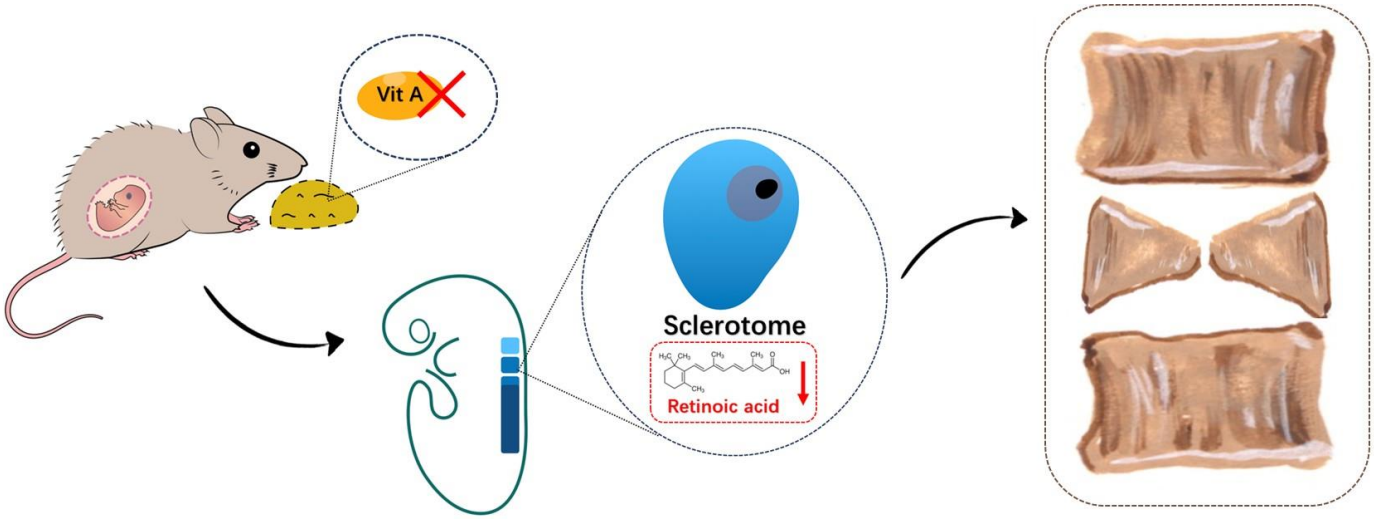

Figure 1: Schematic for vitamin A deficiency induces congenital vertebral malformation via retinoic acid signaling mediated sclerotome dysplasia.

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Paper #92. Experimental Study on the Asymmetric Growth of Vertebral Growth Plate and Neurocentral Synchondrosis Modulated with Microwave Ablation Under CT-Guided for Correcting Early Onset Scoliosis in Immature Porcine †

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Hypothesis
MWA applied to the immature porcine EOS model's convex side's GP and NCS may cause asymmetrical vertebral growth, correcting spinal deformity.

Design
Prospective randomized controlled study.

Introduction
The GP and NCS play a crucial role in the imbalanced vertebral growth in the development of EOS. Existing therapeutic strategies have a dilemma in trauma and deformity correction. However, there is limited literature on minimally invasive interventions for EOS. The study investigated a less invasive treatment approach for early-onset scoliosis (EOS) by inducing asymmetrical growth of the spine. This was achieved by regulating the growth plate (GP) and neurocentral synchondrosis (NCS) on the convex side of the apical vertebrae of the immature porcine EOS model through microwave ablation (MWA).

Methods
To establish an EOS model, unilateral pedicle screw tethering was performed on eighteen 6-week-old pigs to induce a structured spinal curvature. The animals were allocated into three cohorts. The correction group involved eight pigs undergoing CT-guided MWA on the convex side's GP and NCS at the apical vertebra. The sham group was subjected to CT-guided needle puncture at the same-sided GP and NCS without MWA, and the control group entailed five pigs without any intervention. Follow-up entailed monthly spinal radiographs and axial CT imaging.

Results
One month after the spinal tethering procedure, the Cobb's angles were measured at 27.44±1.85° in the established EOS models. All subjects in the correction group demonstrated a reduction in Cobb's angle starting from the first month post-procedure of MWA, with a sustained decrease every subsequent month. In the treatment group, postoperative Cobb's angles were 15.91±1.92°, 12.01±1.97°, and 4.12±1.53° for the first, second, and third months, respectively. No significant reduction in Cobb's angles was observed in either the sham or control groups.

Conclusion
In immature porcine models of EOS, CT-guided unilateral MWA targeting the GP and NCS on the convex side of the apical vertebral has been demonstrated to induce asymmetrical growth of the vertebrae. This innovative application of MWA capitalizes on the differential growth inhibition on the convexity, achieving progressive correction of the scoliotic deformity.

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Paper #93. Examination of an Epigenetic Biomarker for Risk Stratification in Adult Spinal Deformity Surgeries †

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Hypothesis
Increasing epigenetic age is associated with greater risk of poor outcomes in adult spinal deformity (ASD) surgeries.

Design
Post-hoc analysis

Introduction
Epigenetic (EPI) aging is associated with DNA-methylation and -demethylation and offers a measure of biological age distinct from chronological (CHRONO) age. This EPI age is more strongly related to morbidity and mortality in the general population than CHRONO. More accurate risk stratification methods are needed for ASD surgeries.

Methods
A multicenter ASD registry of patients undergoing complex reconstructions was queried. AE were captured prospectively and adjudicated by a surgeon panel. EPI age was calculated per Levine et al using albumin, creatinine, glucose, CRP, lymphocyte count, mean cell volume, red cell distribution width, alkaline phosphatase, white blood cell count, and CHRONO. Correlations validated the EPI clock in ASD. Logistic regression examined the relationship between EPI and risk of adverse AE including those requiring moderate/major intervention and neurologic complications. Pseudo-R2 (measure of model fit) compared models using CHRONO and EPI to estimate risk of AE.

Results
EPI lab data were available for 200 patients. Mean EPI was lower than CHRONO (EPI: 53.7±18.1, CHRONO: 61.1±15.4, p<.001, 95% CI: 6.3-8.5) Increasing CHRONO was associated with higher EPI (Coeff 1.05, p<.001). Overall, with an increasing EPI, there was an increase in risk of AE requiring moderate interventions (OR: 1.05, 95%CI: 1.02-1.08), major intervention (1.06,1.03-1.09), an increase in the risk of symptomatic radiographic AE (OR 1.05, 1.02-1.09) and an increase in risk of neurologic AE (OR 1.04, 1.01-1.07, FIG). Pseudo-R2 were higher for EPI in all four models.

Conclusion
Increasing EPI age is associated with increasing risks of (1) AE requiring major intervention, (2) symptomatic radiographic AE, (3) neurologic AE, with risks greater than estimated by CHRONO. This EPI biomarker may offer an opportunity for more precise risk estimation in ASD surgery. In addition, while chronologic age is linear, epigenetic age may be modifiable thereby offering an opportunity for risk modification prior to surgical intervention.

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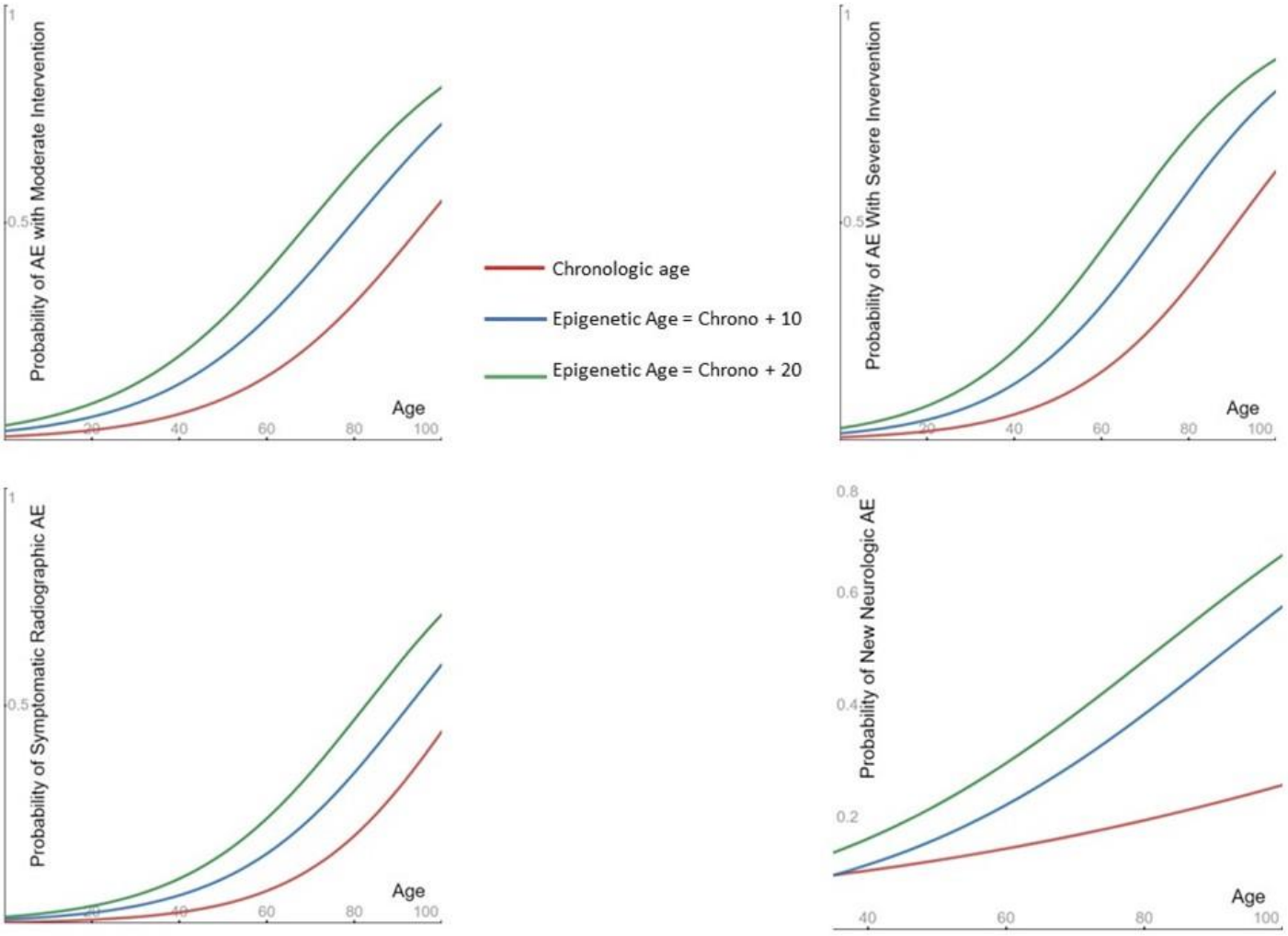

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Paper #94. Efficacy of Topical TXA in Reducing Blood Loss and Transfusion Rates in Spine Surgery: A Double-Blinded Randomized Controlled Trial †

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Hypothesis
Topical TXA will not have a significant impact on blood loss and transfusion rates in spine surgery

Design
Blinded Randomized Controlled Trial

Introduction
Use of IV TXA in spine surgery to help reduce blood loss and transfusions is well-established,however,a paucity of data exists regarding its topical application in spine surgery.Our aim was to assess whether the application of topical TXA locally in addition to parenteral TXA has any additional benefit of reducing periop blood loss and transfusions in patients undergoing major spine surgery.

Methods
A double-blinded RCT was conducted in 59 patients.Patients randomized into the placebo group(PG)received standard intravenous TXA and epinephrine solution topically applied within the surgical incision prior to wound closure;whereas patients randomized into the experimental group(EG)received intravenous TXA and topical TXA solution.Demographic,preop,surgical,and postop data were collected.Study endpoints were compared using univariate methods,and the effect of topical TXA was analyzed using multivariable linear regression.

Results
PG consisted of 32 patients(82.8% idiopathic scoliosis;17.2% non-idiopathic/other),while EG consisted of 27 patients(69.6% idiopathic scoliosis;30.4% non-idiopathic/other).Preop major Cobb,diagnosis,BMI,preop Hb,preop hematocrit,OR time,length of fusion,and surgical approach did not significantly differ between groups.Mean total blood loss was 10.5+/-7.5cc/kg for PG and 12.5+/-7.9cc/kg for EG(p=0.38).Mean volume of autologous and allogeneic blood transfused was not significantly different between the groups(1.74+/-2.93cc/kg vs 3.17+/-4.7cc/kg;0.74+/-2.24cc/kg vs 1.7+/-4cc/kg;(p=0.23;p=0.35)).Major preop coronal Cobb,length of fusion,surgical approach,and non-idiopathic/other diagnosis had significant positive association with total blood loss ($p<0.001$);whereas only diagnosis of non-idiopathic scoliosis/other had a positive correlation with transfusion rates and volume on univariate analysis($p<0.001$).Linear regression did not demonstrate any significant differences between groups for blood loss and transfusion rates.

Conclusion
In this double-blinded RCT the addition of topical TXA within the surgical wound did not display any significant advantage in reducing blood loss or transfusion rates and volume.Further exploration with a larger sample size may be necessary to formulate more conclusive findings.

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Table

Basic Descriptives	ALL	PLACEBO (PG)	TOPICAL TXA (EG)	P-Value
Total Blood Loss(cc/kg)	11.4+/-7.7	10.5+/-7.5	12.5+/-7.9	0.38
Autologous Transfusion Volume(cc/kg)	2.4+/-3.9	1.74+/-2.9	3.17+/-4.7	0.23
Allogeneic Transfusion Volume(cc/kg)	1.2+/-3.1	0.74+/-2.2	1.7+/-4.0	0.35
Transfusion Rates; n (%)	21 (35.6%)	11 (34.4%)	10 (47%)	1
Preop Major Cobb (°)	62.3+/-17.1	63.2+/-17.2	60.9+/-17.4	0.67
OR Time (min)	283+/-75.9	278+/-68.8	289+/-85.2	0.66
Length of Fusion	11.7+/-3.3	11.5+/-3.0	12+/-3.7	0.64
Surgical Approach:				0.55
Posterior Only	38(64.4%)	23(71.9%)	15(55.6%)	
Anterior Only	10(16.9%)	5(15.6%)	5(18.5%)	
Anterior and Posterior	3(5.1%)	1(3.1%)	2(7.4%)	
Diagnosis				0.43
Idiopathic Scoliosis	40(76.9%)	24(82.2%)	16(69.9%)	
Non-Idiopathic/Other	12(23.1%)	5(17.2%)	7(30.4%)	
BMI	29.9+/-61.9	20.6+/-3.3	42.3+/-94.3	0.31
Preop Hb	132+/-27.3	127+/-34	138+/-12.3	0.13
Preop Hematocrit	0.41+/-0.03	0.41+/-0.03	0.42+/-0.04	0.35
Day 1 Hb	100+/-15.5	99.7+/-15	101+/-16.7	0.80
Day 3 Hb	96.7+/-16.4	96.2+/-15.7	97.6+/-17.8	0.80
Total Blood Loss Variables of Interest	**Univariate Analysis**		**Multivariate Analysis**	
	Beta	**P-Value**	**Beta**	**P-Value**
Topical TXA	2.1(-2.5,6.6)	0.38	2.7(-1.7,7.2)	0.2
Preop Major Cobb	0.3(0.2,0.4)	<0.001*	-0.03(-0.2,0.2)	0.8
OR Time	0.03(0.01,0.04)	0.19		
Length of Fusion	1.7(1.2,2,3)	<0.001*	0.3(-0.7,1.3)	0.6
Surgical Approach	16.5(10.3,22,8)	<0.001*	-6.9(-15,1.3)	0.1
Diagnosis	10.4(5.8,15.1)	<0.001*	4.6(-3.5,13)	0.3
BMI	0.01(-0.02,0.03)	0.67		
Preop Hb	0.15(-0.05,0.34)	0.14		
Preop Hematocrit	90.1(21.5,158.7)	0.01*	52(-14,117)	0.1
Day 1 Hb	-0.04(-0.19,0.1)	0.54		
Day 3 Hb	-0.1(-0.23,0.03)	0.15		
Transfusion Variables of Interest	**Univariate Analysis**		**Multivariate Analysis**	
	Beta	**P-Value**	**Beta**	**P-Value**
Topical TXA	2.6(-1.5,6.6)	0.22	2.7(-2.4,7.8)	0.3
Preop Major Cobb	0.2(0.1,0.4)	0.002*	-0.02(-0.2,0.2)	0.8
OR Time	0.01(-0.01,0.04)	0.36		
Length of Fusion	1.1(0.4,1.7)	0.003*	0.24(-0.7,1.2)	0.6
Surgical Approach	1.3(-8.6,11.3)	0.8		
Diagnosis	9.9(5.5,14.3)	<0.001*	12(1.8,22)	0.03*
BMI	0.01(-0.01,0.03)	0.46		
Preop Hb	0.1(-0.1,0.3)	0.21		
Preop Hematocrit	68.1(-1.1,137.3)	0.06		

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