



The Pediatric "Spine at Risk" Program: 9-Year Review of a Novel Safety Screening Tool at a Single Institution

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ABSTRACT

Introduction: Spinal cord injury (SCI) under anesthesia during non-spine procedures for pediatric patients with pre-existing spinal deformities is rare, but serious. A novel EMR-based "Spine At Risk" (SAR) alert program was implemented at our institution in 2011 to identify these patients, trigger evaluation, and document precautions for perioperative positioning and care. We aimed to determine the rate of precautions needed for SAR patients, whether this was higher for those automatically flagged by diagnosis or by physician, and the success of the program based on number of SCI's during this time. **Methods:** We performed a retrospective chart review for all patients with a SAR alert from 2011-19, categorized by whether the patient was flagged by the system (based on an at-risk diagnosis) or assigned a SAR alert by a provider. We recorded whether and which precaution recommendations were made, as well as intraoperative SCI's. **Results:** Of the 3442 patients in the study, 1953 had a SAR alert activated due to a diagnosis and 1489 had an alert added by a provider. The system was 62.5% better than providers at identifying patients who needed precautions ($p < 0.001$). For the diagnosis-flagged patients, 39% received at least one precaution form with rates for intraoperative recommendations as follows (reported as % of all forms): spinal cord monitoring (25%), fiberoptic intubation (14%), avoid c-spine flexion/extension/rotation (87%), avoid thoracolumbar flexion/extension/rotation (16%). 24% of provider-flagged patients received at least one precaution form with these recommendation rates at 6%, 6%, 30%, and 8%, respectively. No intraoperative SCI's occurred for these patients during the study. **Conclusions:** This study provides a long-term look at a novel safety program that was designed to prevent devastating SCI's in high-risk pediatric patients during non-spine anesthetized procedures. It was found that the system was better than providers at identifying patients who needed precautions, cervical spine precautions were the most common intervention, and no intraoperative SCI's occurred in these patients during the study. This program may serve as a model for others to apply to high-risk spines.

INTRODUCTION

- ❖ Pediatric patients with pre-existing spinal deformities are at higher risk of spinal cord injury (SCI) under general anesthesia during non-spine procedures
- ❖ In 2011, Seattle Children's Hospital developed the "Spine at Risk" (SAR) EMR-based alert program to prevent intraoperative SCI's in this population
- ❖ SAR allows for evaluation and documentation of recommendations for perioperative positioning and care in a clear, concise, single form that is easily accessible to the surgical team
- ❖ Patients are flagged for SAR either automatically by the system if they have a qualifying diagnosis (Figure 1) or manually by a provider
- ❖ Studying the outcomes of the SAR program, specifically, how often certain precautions were needed and how many SCI's occurred in this population during the study, allows for evidence of whether this program has been beneficial

| Diagnosis |
|--|
| Cervical Spinal Cord Injury |
| Cervical Spine Fracture |
| Chondrodystrophy |
| Collapsed Vertebrae |
| Diastematomyelia |
| Dislocation of C1/C2 Cervical Vertebrae |
| Dislocation of Unspecified Cervical Vertebrae |
| Displacement of Cervical or Thoracic Disc |
| Immunodeficiency with Short-Limbed Stature |
| Intraspinial Abscess |
| Klippel-Feil Syndrome |
| Mucopolysaccharidosis |
| Neoplasm of Spinal Cord |
| Neoplasm of Vertebral Column |
| Osteogenesis Imperfecta |
| Other Congenital Anomalies of Ribs and Sternum |
| Other Congenital Osteodystrophies |
| Paraplegia |
| Pathologic Fracture of Other Specified Site |
| Polycystic Fibrous Dysplasia of Bone |
| Spinal Instabilities, Lumbosacral, Sacral, and Sacrocaudal Region |
| Spinal Stenosis of Cervical Region |
| Spine Instability |
| Stress Fracture of Spine |
| Thoracic and/or Lumbar Spinal Cord Injury |
| Thoracic and/or Lumbar Spine Fracture |
| Unspecified Displacement of Disc |
| Unspecified Musculoskeletal Disorders and Symptoms Referable to Neck |

Figure 1. Diagnoses that automatically qualify a patient for SAR.

We performed a retrospective chart review containing all patients with a SAR alert from 2011-2019. We then documented:

1. If the patient had a diagnosis that qualified them for SAR or if the alert was added manually by a provider
2. If the patient had at least one precaution form filled out during the study
3. Which precaution recommendations were made on the precaution form (Figure 2)

Figure 2. Example SAR precaution form.

METHODS

RESULTS

| | Count for Alert Activated Automatically By Diagnosis | Count for Alert Added Manually By Provider |
|--|--|--|
| Number of Patients With SAR Alert | 1953 | 1489 |
| Number of Patients Receiving 1+ Precaution Form | 759 | 362 |
| Total Number of Precaution Forms Completed During Study | 1313 | 457 |
| Precaution Form Response Factors (reported as number of forms total with that recommendation) | | |
| Critical Precautions | | |
| > difficult airway | 25 | 4 |
| > chest at risk | 14 | 3 |
| > malignant hyperthermia/susceptible | 0 | 0 |
| > spine at risk | 882 | 375 |
| Reasons Critical Precautions | | |
| > in one year | 530 | 99 |
| > in two years | 121 | 43 |
| > in three years | 145 | 116 |
| > never | 142 | 118 |
| Primary Service for Precautions | | |
| > orthopedics | 1182 | 453 |
| Diagnosis Spine Precautions | 219 | 36 |
| General Recommendations | | |
| > no special precautions needed - standard positioning and care | 537 | 351 |
| > spinal cord monitoring for anesthetized procedures >45 minutes | 391 | 28 |
| > avoid multiple procedures involving transfers under single anesthesia if possible | 314 | 34 |
| Cervical Spine Precautions | | |
| > cervical collar on when in hospital whenever possible | 57 | 10 |
| > fiberoptic intubation | 183 | 26 |
| > avoid neck flexion and forward translation | 571 | 71 |
| > avoid neck extension and posterior translation | 370 | 52 |
| > avoid neck rotation | 197 | 14 |
| > sandbags on side of head | 10 | 1 |
| > discuss disorientation on road to avoid flexion/rotation/translation of skull | 83 | 0 |
| Thoracic and Lumbar Spine Precautions | | |
| > avoid thoracolumbar extension | 38 | 12 |
| > avoid thoracolumbar flexion | 121 | 15 |
| > avoid thoracolumbar rotation | 35 | 9 |
| Post-Operative Recommendations | | |
| > no spinal or epidural anesthesia given until 8 hours postop and documented normal neurological exam | 562 | 99 |
| > anesthetic plan allows for rapid emergence to allow neurological exam in recovery room within 1 hour | 628 | 106 |
| > nursing orders in PACU to provide for awakening to level of consciousness that allows good neurological exam by surgical team before re-sedation | 577 | 102 |

Figure 3. SAR resulting precautions, categorized as patients with an automatic SAR flag due to a diagnosis or manually-added alert. Some patients have received more than one SAR precaution form over the study duration. Thus, the number of precaution forms exceeds the number of patients needing precautions.

RESULTS

- ❖ 3442 patients with SAR alert activated (Figure 3)
 - ❖ 1953 diagnosis-flagged (39% needed precautions)
 - ❖ 1489 provider-flagged (24% needed precautions)
- ❖ Diagnosis-flagging system was 62.5% better than providers at identifying patients who would need precautions following evaluation ($p < 0.001$)

| Intervention: | Diagnosis-Flagged Rates | Provider-Flagged Rates |
|---------------------------|-------------------------|------------------------|
| Spinal Cord Monitoring | 25% | 6% |
| Fiberoptic Intubation | 14% | 6% |
| C-Spine Precautions | 87% | 30% |
| Thoracolumbar Precautions | 16% | 8% |

Figure 4. Precaution recommendation rates categorized as patients with an automatic SAR flag due to a diagnosis or manually-added alert. Precaution rates reported as percentage of all precaution forms containing that recommendation. Cervical spine precautions were the most frequently documented recommendations.

No intraoperative spinal cord injuries occurred in this population during the study.

CONCLUSIONS

- ❖ The SAR diagnosis-based system is highly effective for automatically flagging patients who warrant precautions
- ❖ Cervical spine precautions are needed most frequently
- ❖ The absence of SCI's in this population during the study highlights the program's effectiveness in ensuring patient safety
- ❖ The program can serve as a model for other institutions
- ❖ Future directions:
 - ❖ Cost to the institution to maintain the SAR program
 - ❖ Patient burden of the SAR program (extra imaging studies, clinic visits, associated costs, etc.)
 - ❖ Frequency of intraoperative neuromonitoring (spinal cord monitoring) signal changes in patients receiving that precaution

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