Risk factors of unintended return to the operating room in adult spinal deformity

Lung Chan†, Yue Li‡, Yong Hai*, Yuzeng Liu and Yangpu Zhang

Abstract

Background: To evaluate the incidence and risk factors associated with unintended return to the operating room in adult spinal deformity after spinal deformity corrective surgery.

Methods: Retrospect of 141 adult spinal deformity patients in a single institution between January 2017 and December 2019. Inclusion criteria enrolled 18 to 80 years old patients who diagnosed with congenital/idiopathic/syndromic/acquired spinal deformity underwent posterior corrective spinal surgery. The surgical details and complications were recorded. The rate of unintended return to the operating room (UIROR) during hospitalization was examined, and the risk factors of unintended return to the operating room were investigated via multivariate analysis.

Results: This is a retrospective study. One hundred and forty-one patients who underwent spinal deformity surgery with a mean age of 31.8 years (range 18-69 years) were studied. The rate of unintended return to the operating room was 10.64% (15/141). Two of 15 patients had twice unintended surgery during hospitalization (13.33%). The most principal complication was neurologic deficit (73.3%); six of 15 postoperative present implants deviation causes severe lower limbs radiating pain (40%). The multivariate analysis shows higher apical vertebral rotation (AVR>grade II, odds ratio [OR] = 9.362; 95% CI= 1.930-45.420; P= .006), obesity (OR = 11.448; 95% CI= 1.320-99.263; P= .027), and previous neurological symptom (OR = 7.358; 95% CI= 1.798-30.108; P= .006) were independent predictors of unintended return to the operating room.

Conclusion: Postoperative neurologic deficit and short-term implant malposition are essential causes of unintended return to the operating room in adult spinal deformity patients. Preoperative factors such as higher AVR (> grade II), obesity, and previous neurological symptom may significantly increase the risk of morbidity in UIROR. Spine surgeons should be alert to these risk factors and require adequate preoperative evaluations to reduce the incidence of unintended return to the operating room.

Keywords: Adult spinal deformity, Unintended return to OR, Apical vertebral rotation, Neurologic deficit, Implant malposition

Introduction

Adult spinal deformity (ASD) includes not only the coronal and sagittal deformities but also rotational subluxation and axial plane deformity, is an increasing public health concern, people of any age and gender may suffer from spinal deformity [1, 2]. ASD may develop from congenital, idiopathic spinal deformities in childhood and adolescence, or due to degenerative changes in intervertebral disks and facet joints [3–6]. ASD may also be the result of trauma, tumor, infection, or inflammation affecting the spine. According to reports, the prevalence of ASD in the general population is as high as 32% [5, 6], ASD patients may experience symptoms related to pain, the progression of deformity, coronal or sagittal malalignment, and/or neurologic deficit [7].
Corrective surgery for ASD is a complex procedure that aims to reduce pain, disability, the progression of the deformity, and improving function [8, 9]. Several authors reported ASD corrective surgery may be technically challenging, and adverse events often occur with a high rate of perioperative and postoperative complications (26.8% to 42%) [10–15]. In previous studies, complex ASD corrective surgery has been associated with a series of complications, such as wound infection, proximal or distal junctional failure, neurological deficits, and acute hemorrhagic anemia [16]. Some complications required surgical intervention in time after primary surgery. In the past 3 years, the complication rate in the author’s hospital was 27.6%; the most common cause was neurological deficit (14.9%), followed by wound infection (10.6%). A total of 38.4% of patients with complications need UIROR during hospitalization.

UIROR during hospitalization is an unexpected outcome, causing psychological, physical, and financial burden on patients with spinal deformity. Causes associated with UIROR include neurological complications, internal fixation deviations, and surgical site infections. This situation has become increasingly important in recent years. The Scoliosis Research Society Morbidity and Mortality Committee (SRS M&M) has enrolled the data of UIROR since 2017. Thus far, the SRS database has been used to report the M&M of idiopathic, congenital, neuromuscular, and other scoliosis and kyphosis. Therefore, the rate of UIROR after spinal corrective surgery cannot be underestimated. No previous reports on UIROR for patients undergoing spinal deformity surgery. Its risk factors remain undefined.

The goal of our research is to evaluate the incidence, causes, and risk factors associated with UIROR after ASD surgery.

Materials and methods

This is a retrospective study. At the present study, we enrolled 141 consecutive patients who were diagnosed with ASD to evaluate radiologic and clinical outcomes between January 2017 and December 2019 and performed posterior instrumented corrective spinal surgery by 1 surgeon in a single institution. The patients were grouped based on whether they returned to OR unintended during hospitalization or not. This study was approved by the appropriate institutional review board of Beijing Chao-Yang Hospital. The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Included criteria are as follows: (1) Age 18 to 80 years old inclusive. (2) Congenital deformity (failure of formation and/or segmentation, kyphosis). (3) Idiopathic, syndromic or acquired scoliosis, kyphosis, or kyphoscoliosis. (4) Underwent corrective spinal surgery via the posterior approach.

Excluded criteria are as follows: (1) Underage or over-age. (2) Patients with active infection. (3) With spinal tumor. (4) Underwent corrective spinal surgery via non-posterior approach (anterior or lateral). (5) Incomplete clinical data.

Data collection

Clinical and radiographic measurements were obtained through the clinical records preoperatively; postoperatively for the 141 patients who met the inclusion criteria, the following information (Table 1) was collected: demographic characteristics (age, gender, body mass index, duration of spinal deformity history), surgical characteristics (total operative time, intraoperative estimated blood loss, spinal osteotomy, American Society of Anesthesiologists Classification, total fusion levels, and curve correction rate), radiographic characteristics (Cobb angle of main curves, curve flexibility, and apical vertebral rotation). There were 49 idiopathic scoliosis, 63 congenital deformities, 8 neurofibromatosis scoliosis [NFS], 5 neuromuscular scoliosis [NMS], 5 post-tuberculotic deformity [PTBD], 5 ankyllosing spondylitis kyphosis, 3 post-polio myelitis scoliosis [PPS], 2 post-traumatic deformity [PTD], 1 Scheuermann’s kyphosis (Fig. 1). The main outcome measures examined were UIROR occurring during hospitalization.

Table 1 Baseline characteristics of patients recruited in the study

| Characteristic                        | n (%) or mean ± SD |
|---------------------------------------|--------------------|
| Age                                   | 31.80±12.51        |
| Gender (male/female)                  | 49/92              |
| Body mass index (BMI)                 | 22.23±3.99         |
| Underweight                           | 22 (15.6%)         |
| Healthy weight                        | 79 (56%)           |
| Overweight                            | 31 (22%)           |
| Obesity                               | 9 (6.4%)           |
| Previous spine surgery (yes/no)       | 18/123             |
| Number of fusion vertebrae            | 10.82±3.35         |
| 2-6                                   | 22 (15.6%)         |
| 7-12                                  | 66 (46.8%)         |
| 13+                                   | 53 (37.6%)         |
| Mean operative time in min            | 291.67±85.99       |
| Intraoperative estimated blood loss in ml | 836.52±641.34    |
| Osteotomy                             | 89/52              |
| Thoracoplasty                         | 26/115             |
| Fusion to sacrum                      | 11/130             |

BMI: body mass index
Statistical analysis
IBM SPSS Statistics V18 x32 was used to perform all descriptive and comparative analyses. Univariate analyses were performed to examine the relationship between demographics-operative parameters and the two outcomes of interest by using t test or $\chi^2$ test for data comparison. A multivariate logistical regression analysis was performed, adjusting for the duration of the spinal deformity history, obesity (BMI > 30 kg/m²), previous lower extremity neurological symptoms, AVR (based on Nash-Moe grading system), and congenital deformity. Variables that showed a univariate association with UIROR with a $P$ value less than 0.05 were included in the forward-stepwise selection model. All statistical comparisons were considered significant with a $P$ value less than 0.05.

Results
Demographics of the study sample
A total of 141 consecutive patients met the inclusion criteria (Table 1). The mean ± standard deviation age was 31.8±12.51 years and 65.2% of the patients were female and a mean BMI of 22.2±3.98 (range 15.1 to 35.2). Thirty-one (22%) of the study population was defined as overweight, nine (6.4%) of the study population was defined as obesity. The most primary diagnoses included congenital deformity (44.7%) and adult idiopathic scoliosis (34.8%). Eighteen (12.8%) of these patients had a previous spinal surgery history. The mean of total fusion levels were 10.82±3.35 with a range of 2 to 17 levels. Sixty-six (46.8%) of the patients underwent instrumented fusion of 7 to 12 vertebral segments. Eighty-nine (63.1%) of the patients underwent osteotomies, forty-three (48.3%) of 89 patients underwent grade 2 osteotomies, twenty-five (28.1%) patients underwent grade 5 or 6 osteotomies. The mean total operative time was 291.67±85.99 min, with a mean intraoperative estimated blood loss was 836.52±641.34 ml.

Incidence rates and causes of UIROR
There were 15 patients (10.6%) who required UIROR during hospitalization. The median number of days after index corrective spinal surgery were 10.1 days (range 3 to 18). Two of 15 patients had twice unintended surgery during hospitalization (13.3%). The most common incident for UIROR was implants deviation causes severe lower limbs radiating pain (40%), followed by lower limbs paralysis (26.8%). Other indications included implants malposition found by computed tomography (CT) scan without any symptoms (20%), lower limbs paresthesia (6.6%), and wound infection (6.6%).

Risk factors for UIROR
Fifteen UIROR patients and 126 non-UIROR patients with an average age of 34.47±14.95 (range 19–66) years and 31.48±12.22 (range 18–69) years, a mean BMI of UIROR were 25.05±4.93 kg/m² (range 17.8–35.2) versus non-UIROR were 21.89±3.74 kg/m² (range 15.1–34.9). Eleven (73.3%) of UIROR patients were diagnosed with congenital deformity. There was no significant difference in UIROR rate with any of the enrolled diagnoses. Patients in UIROR group with longer history of spinal deformity (26.2±15.32 years vs 18.9±12.6 years, $P = .040$). The factors that were significantly associated with UIROR are summarized in Table 2. The percentage of obese patients was significantly higher in the UIROR group (20.0% vs 4.8%, $P = .046$), as well as the percentage of patients with higher apical vertebral rotation (73.3% vs 37.3%, $P = .011$), and patients with preoperative neurological symptoms (66.7% vs 23.0%, $P = .046$).
There was no statistically significant difference in other preoperative demographic data and imaging data between UIROR and non-UIROR group. The final multivariate regression (Table 3) for UIROR included duration of spinal deformity history, congenital deformity or not, higher apical vertebral rotation (AVR, OR = 9.362; 95% CI= 1.930-45.420; P= .006*), obesity (OR = 11.448; 95% CI= 1.320-99.263; P= .027*), and previous neurological symptom (R = 7.358; 95% CI= 1.798-30.108; P= .006*).

### Discussion

ASD is an increasing public health concern, people of any age and gender may suffer from spinal deformity. Patients who undergo spinal corrective surgery may improve their quality of life. The rate of complications reported in the literature varies widely, ranging from 26.8 to 42% [10–15]. Urgent and severe complications may require UIROR. UIROR during hospitalization is an unexpected outcome, causing psychological, physical, and financial burden on patients with ASD. Nearly half of the UIROR patients because of postoperative severe lower limbs radiating pain caused by implants deviation.

As ASD patients grow older, the severity of the spinal deformity may also increase. Previous literature has proven that the incidence of complications in elderly patients has increased [17–19]. In this study, the age of the UIROR group was slightly older than that of the non-

### Table 2 Univariate analysis of UIROR risk factors

| Parameters                        | UIROR          | Non-UIROR       | P     |
|-----------------------------------|----------------|-----------------|-------|
| **Patient-related**               |                |                 |       |
| Age (years)                       | 34.47±14.95    | 31.48±12.22     | .385  |
| Gender (male/female)              | 7/8            | 42/84           | .391  |
| Obesity (obese/none)              | 3/12           | 6/120           | .046* |
| Previous spine surgery history    | 0/15           | 18/108          | .217  |
| Duration of spinal deformity      | 26.20±15.32    | 18.86±12.62     | .040* |
| Previous neurological symptom     | 10/5           | 29/97           | .001* |
| Congenital deformity              | 11/4           | 52/74           | .026* |
| **Radiographic**                  |                |                 |       |
| Preoperative Cobb angle of main curve (°) | 91.61±30.34 | 89.62±36.09     | .838  |
| Preoperative flexibility of main curve (%) | 16.20±16.98 | 14.37±14.55     | .652  |
| Preoperative maximum kyphosis angle (°) | 77.56±37.87 | 72.23±43.32     | .649  |
| Preoperative AVR (>II/<II)        | 11/4           | 47/79           | .011* |
| **Surgery related**               |                |                 |       |
| Total operative time (min)        | 317.00±110.01  | 288.65±82.71    | .154  |
| Intraoperative estimated blood loss (ml) | 1060.00±701.83 | 809.92±631.51 | .154 |
| Number of fusion vertebrae        | 10.20±3.34     | 10.89±3.36      | .454  |
| ASA (>2/<2)                       | 1/14           | 33/93           | .118  |
| Osteotomy (yes/no)                | 10/5           | 79/47           | .501  |
| Thoracoplasty (yes/no)            | 3/12           | 23/103          | .550  |
| Fusion to sacrum (yes/no)         | 3/12           | 8/118           | .096  |

AVR apical vertebral rotation, ASA American Society of Anesthesiologists

*P < 0.05, statistically significant difference between the two groups

### Table 3 Multivariate analysis of UIROR risk factors

| Parameters                        | B    | SE   | Ward  | df  | P     | Exp(B) |
|-----------------------------------|------|------|-------|-----|-------|--------|
| Obesity                           | 2.438| 1.102| 4.894 | 1   | .027* | 11.448 |
| Duration of spinal deformity history | .017 | .024 | .513  | 1   | .474  | 1.017  |
| Previous neurological symptom     | 1.996| .719 | 7.707 | 1   | .006* | 7.358  |
| Congenital deformity              | −1.330| .725 | 3.370 | 1   | .066  | .264   |
| AVR >II                           | 2.237| .806 | 7.706 | 1   | .006* | 9.362  |

AVR apical vertebral rotation

*P < 0.05, statistically significant
In our study, three patients underwent spinal corrective surgery for ASD patients treated with long fusions to the sacropelvis, the rate of return to the OR was 27.6%. In the univariate analysis in our series. However, there are differences between our study and the above literature, which may be caused by the different time points of the clinical observation results.

Postoperative neurological complication is one of the reasons for UIROR. In a multicenter, prospective, worldwide observational study, Lenke et al. [23] found a higher rate of postoperative neurologic deficit in patients with a preoperative neurologic deficit compared with patients without preoperative deficit (25.76% vs 22.17%, P < .0001). Kim et al. [24] reviewed 233 patients with ASD who underwent posterior vertebral resection, the preoperative neurologic deficit significantly increased complications (OR = 5.55, P = .0004). In this study, previous lower limbs neurological symptom is also an essential preoperative predictor (OR = 7.358; P = .006).

The finding of the current study can be presented in the following case examples. Patient A (Fig. 2) was a 52-year-old woman with complex congenital kyphoscoliosis. She is obese (BMI=30.4). She had neurologic deficits for more than 20 years. Preoperative standing posteroanterior spine radiograph showed the AVR is grade IV. She underwent spinal fusion from T9 to S1 and L1/L2 vertebral column resection (VCR), with an operative duration of 320 min and estimated blood loss of 600 ml. On postoperative day 4, she developed severe left lower limb radiating pain, postoperative CT scan demonstrated that left L2 pedicle screw deviation. UIROR was performed on postoperative day 5. Patient A’s radiating pain was significantly relieved after implant adjustive and decompressive surgery.

There are still some limitations for our study. First, this is a retrospective single-institution study and thus the results may not be generalizable to other institutions. The relatively small sample size may have reduced the statistical significance to some extent, but all surgeries were performed by the same experienced surgeon and it shows predictors for UIROR in ASD surgery. We should expand the sample size in future work. Future study should consider the psychological, physical burden, and cost analysis which would improve our standing of the mental and financial impact of UIROR on ASD patients.
In summary, the rate of UIROR after posterior corrective spinal surgery in this single institutional study was 10.6%. Postoperative neurologic deficit and short-term implant malposition are the main causes of UIROR. The risk factors of UIROR in ASD patients were preoperative AVR > grade II, obesity, and previous neurological symptom. Spine surgeons should be alert to these risk factors and require adequate preoperative evaluations for ASD patients to reduce the incidence of UIROR. This study can be used as an initial model for predicting UIROR in the study population.

**Conclusion**

**Abbreviations**
UIROR: Unintended return to the operating room; ASD: Adult spinal deformity; AVR: Apical vertebral rotation; OR: Odds ratio; BMI: Body mass index; SRS M&M: Scoliosis Research Society Morbidity and Mortality Committee; NFS: Neurofibromatosis scoliosis; NMS: Neuromuscular scoliosis; PTBD: Post-tuberculotic deformity; PPS: Post-polioymelitis scoliosis; PTD: Post-traumatic deformity

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**Authors’ contributions**
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Li. (V) Data analysis and interpretation: Lung Chan, Yangpu Zhang. (Vi) Manuscript writing: All authors. (VII) Final approval of manuscript: All authors.

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Availability of data and materials
The data used and analyzed in this study is included in the article or are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The study complied with the Declaration of Helsinki and was approved by the Ethics Committee of Beijing Chaoyang Hospital (No. 2020-D.-451-2). Participant informed consent was exempted because of the retrospective study design, and the study design was approved by the appropriate ethics review board.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no conflict of interest.

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