Postoperative Enhanced Recovery Management Protocol and Outcome Assessment for Adolescent Idiopathic Scoliosis: Postprint

Authors: Cai Siyi, Qiu Guixing, Wang Yipeng, Zhang Jianguo, field, Zhao Hong, Zhao Yu, Li Shugang, Shen Jianxiong, Li Mohan

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Abstract

Objective To summarize the comprehensive measures of enhanced recovery after surgery (ERAS) for adolescent idiopathic scoliosis and evaluate its impact on postoperative recovery. Methods From January 2007 to January 2017, the first 100 cases (cases 1-100, conventional group) and the last 100 cases (cases 1193-1292, ERAS group) in a consecutive cohort of adolescent idiopathic scoliosis patients hospitalized for surgical orthopedic treatment in the Department of Orthopedics, Peking Union Medical College Hospital were enrolled in this study. The ERAS group adopted an enhanced recovery protocol including preoperative, intraoperative, and postoperative measures during the perioperative period. Postoperative recovery was retrospectively compared between the two groups, including total hospital stay, postoperative hospital stay, allogeneic transfusion volume, pain score at discharge, complication rate within 30 days, and unplanned reoperation rate within 1 year. Results There was no statistically significant difference in general clinical data and unplanned reoperation rate within 1 year between the two groups. The total hospital stay and postoperative hospital stay in the conventional group were significantly longer than those in the ERAS group [total hospital stay: conventional group (17.18±2.67) d, ERAS group (11.35±1.49) d, $P<0.05$; postoperative hospital stay: conventional group (9.34±0.52) d, ERAS group (7.19±0.71) d, $P<0.05$]. The number of patients receiving allogeneic transfusion [conventional group 41% (41/100), ERAS group 20% (20/100), $P<0.05$] and allogeneic red blood cell transfusion volume [conventional group (1.43±0.39) U, ERAS group (0.59±0.12) U, $P<0.05$] in the conventional group were both higher than those in the ERAS group. The pain score at discharge in the conventional group [(3.40±0.63) points] was slightly higher than that in the ERAS group [(3.00±0.47) points], with no statistically significant difference. Conclusion Implementing an enhanced recovery protocol during the perioperative period for adolescent idiopathic scoliosis can reduce

hospital stay and transfusion volume, and accelerate patient recovery without increasing the incidence of complications and unplanned reoperation.

Full Text

Enhanced Recovery After Surgery Program in the Perioperative Management of Adolescent Idiopathic Scoliosis and Its Effectiveness Evaluation

Cai Siyi[1], Qiu Guixing[1], Wang Yipeng[1], Zhang Jianguo[1], Zhao Hong[1], Zhao Yu[1], Li Shugang[1], Shen Jianxiong[1], Tian Ye[1], Li Mohan[2]

[1]Department of Orthopedics, Peking Union Medical College Hospital, [2]Chinese Academy of Medical Sciences & Peking Union Medical College, Beijing 100730, China

Corresponding author: Shen Jianxiong, Tel: 010-69152801, E-mail: sjxpumch@163.com

Abstract

Objective: This study aimed to summarize the integrated enhanced recovery after surgery (ERAS) program in the perioperative management of adolescent idiopathic scoliosis (AIS) and evaluate its impact on postoperative recovery.

Methods: Among the continuous cohort of AIS patients who underwent orthopedic surgery at Peking Union Medical College Hospital between January 2007 and January 2017, the initial 100 cases (Cases 1–100, traditional group) and the last 100 cases (Cases 1193–1292, ERAS group) were enrolled in this study. The ERAS group received comprehensive enhanced recovery management protocols covering the preoperative, intraoperative, and postoperative periods. Related recovery indicators were compared between the two groups, including total length of stay, postoperative length of stay, allogeneic blood transfusion, pain scores at discharge, incidence of complications within 30 days, and incidence of unplanned reoperation within one year.

Results: There were no statistically significant differences between the two groups in gender, age, body mass index, surgical segments, or the incidence of unplanned reoperation within one year. However, the total length of stay and postoperative length of stay in the traditional group were significantly longer than those in the ERAS group [Total length of stay: traditional group (17.18±2.67) days, ERAS group (11.35±1.49) days; Postoperative length of stay: traditional group (9.34±0.52) days, ERAS group (7.19±0.71) days, $P<0.05$]. Both the percentage and volume of allogeneic blood transfusion in the traditional group were higher than those in the ERAS group [Percentage: traditional group 41% (41/100), ERAS group 20% (20/100), $P<0.05$; Volume: traditional group (1.43±0.39) U, ERAS group (0.59±0.12) U, $P<0.05$]. The pain scores at discharge for the traditional group [(3.40±0.63) points] were slightly higher

than those of the ERAS group [(3.00±0.47) points], but this difference was not statistically significant.

Conclusions: Implementation of an accelerated rehabilitation protocol during the perioperative period for adolescent idiopathic scoliosis can reduce hospital stay and blood transfusion requirements while accelerating patient recovery, without increasing the incidence of complications or unplanned reoperation.

Keywords: enhanced recovery after surgery; adolescent idiopathic scoliosis; length of hospital stay; blood transfusion

Introduction

In 1997, Danish scholar Henrik Kehlet proposed the concept of "multimodal approach to control postoperative pathophysiology and rehabilitation," which gradually evolved into the "enhanced recovery after surgery (ERAS)" theory and was widely promoted in gastrointestinal surgery. ERAS protocols have been shown to significantly reduce postoperative cardiovascular events, delirium, and cognitive dysfunction while markedly shortening hospital stays. The ERAS concept was first applied in orthopedics to joint arthroplasty, where it successfully reduced postoperative hospitalization to 1–3 days. However, there remains limited research on the application of ERAS in spinal deformity surgery.

The incidence of adolescent idiopathic scoliosis is 2–3%, with surgical intervention required for severe cases where the main coronal curve exceeds 40–45°. While surgical techniques for AIS have become relatively standardized, perioperative management strategies require further improvement. Severe scoliosis can affect cardiopulmonary function and abdominal organ positioning, and patients face numerous postoperative challenges including anemia, physiological dysfunction, and perioperative anxiety. Without scientific and effective management, these factors often lead to prolonged hospitalization and delayed functional recovery, increasing the social medical burden. Therefore, developing effective interventions to accelerate postoperative recovery represents the next direction for improvement in surgical treatment.

1. Materials and Methods

1.1 Study Subjects This retrospective continuous cohort study of adolescent idiopathic scoliosis patients was approved by the Ethics Committee of Peking Union Medical College Hospital. The study included patients who: (1) underwent one-stage posterior corrective surgery for AIS, (2) were between 10–18 years of age, and (3) had no other diseases causing scoliosis. Exclusion criteria comprised: (1) other types of scoliosis, (2) presence of other spinal diseases, and (3) use of three-column osteotomy techniques during posterior corrective

surgery. All surgical procedures were performed by attending surgeons with independent experience in scoliosis correction for over five years.

1.2 Surgical Strategy for Scoliosis Under the guidance of the PUMC classification system for idiopathic scoliosis, all patients underwent appropriate selection of fusion segments, adopting a selective fusion strategy that fuses only the necessary segments to achieve good correction while reducing surgical trauma. Over the past decade, surgical techniques for adolescent idiopathic scoliosis have become standardized, providing a foundation for implementing effective interventions to accelerate postoperative recovery.

1.3 Grouping 1.3.1 Traditional Group: This study retrospectively reviewed the initial 100 cases (Cases 1–100) in the continuous cohort of adolescent idiopathic scoliosis patients who underwent surgical treatment at Peking Union Medical College Hospital between January 2007 and January 2017. These patients received traditional perioperative management, as a comprehensive perioperative management pathway had not yet been established during this period.

1.3.2 ERAS Group: The last 100 cases in the cohort (Cases 1193–1292) were enrolled, with an enrollment period from January 2017 to January 2017. These patients received the current consensus-based enhanced recovery protocol and clinical pathway.

1.4 ERAS Management Protocol The perioperative enhanced recovery protocol for adolescent idiopathic scoliosis at Peking Union Medical College Hospital was gradually developed and refined during this period. The protocol includes the following components:

1.4.1 Preoperative Assessment and Education

1.4.1.1 Surgical and Psychological Education: Through educational manuals and one-on-one conversations, patients and families were informed about preoperative examinations, specialist consultations, dietary management, potential postoperative discomforts (including indwelling catheters, reduced gastrointestinal function due to general anesthesia), expected surgical outcomes, and follow-up plans. The importance of early rehabilitation was emphasized, and patients were taught axial turning techniques while families learned how to assist patients in moving from side-lying to sitting positions.

1.4.1.2 Nutritional Status Assessment and Intervention: Malnutrition increases postoperative complication rates. Plasma protein and lymphocyte levels decrease after scoliosis surgery, and hypoalbuminemia is associated with spinal surgery infection. Low body weight patients are at higher risk. All patients with preoperative plasma protein <3.5 g/dl or BMI <18.5 kg/m^2 received nutritional intervention.

1.4.1.3 Cardiopulmonary Function Assessment: Although adolescent idiopathic scoliosis patients generally have no cardiopulmonary structural abnormalities,

severe deformities may be accompanied by restrictive ventilatory dysfunction. Cardiac function was evaluated through ECG, echocardiography, pulmonary function tests, and blood gas analysis. Patients with respiratory dysfunction or hypoxemia were referred to the anesthesia clinic for further surgical risk assessment.

1.4.1.4 Discharge Planning Education: Patients and families were informed of discharge criteria in advance, including good internal fixation position, ability to ambulate, pain controlled with oral medication reaching NRS 3, stable vital signs, and no significant nausea or vomiting. Post-discharge follow-up and rehabilitation plans were also communicated.

1.4.2 Perioperative Interventions

1.4.2.1 Anesthesia Management: General anesthesia was administered. The focus of intervention was accurate surgical judgment and meticulous, precise intraoperative operation.

1.4.2.2 Standardized Surgical Technique: The entire surgical process employed standardized techniques under the principle of minimal trauma, including proper positioning, protection of compressed areas, routine use of bipolar electrocautery to reduce intraoperative bleeding, and routine intraoperative spinal cord electrophysiological monitoring to improve surgical safety.

1.4.2.3 Blood Management: Comprehensive whole-course blood management measures were implemented. Anemia was assessed and treated preoperatively. For intraoperative blood loss reaching 20% of total blood volume, controlled hypotension was applied with systolic pressure reduced to 80–90 mmHg or mean arterial pressure to 50–65 mmHg. Intraoperative cell salvage was used to reduce allogeneic transfusion. Postoperatively, incision drainage and drainage volume were closely monitored, with hemoglobin levels and hematocrit changes tracked for timely transfusion or oral erythropoietin administration.

1.4.2.4 Fluid Management: A perioperative restrictive fluid therapy strategy was employed, using both crystalloid and colloid solutions while stopping intravenous fluids as early as possible.

1.4.2.5 Gastrointestinal Management: Orthopedic surgical correction can cause abdominal visceral traction, and factors such as bed rest can lead to abdominal distension. Postoperative nausea and vomiting were prevented with prophylactic gastrointestinal prokinetic drugs and antiemetics. Patients began eating after awakening from anesthesia. If nausea and vomiting occurred, medications were discontinued promptly to avoid excessive electrolyte loss from vomiting.

1.4.2.6 Urinary Catheter Management: Traditional fasting times could cause patient discomfort and increase insulin resistance. Some national anesthesia associations have adjusted fasting protocols, allowing small amounts of water or carbohydrate drinks 4–6 hours preoperatively. The ERAS group patients consumed 200 ml of 12.5% carbohydrate solution 4–6 hours before surgery. Postoperative urinary catheters were intermittently clamped early and removed as soon

as possible to reduce urethral discomfort and abnormal urination. Attempted removal was made once patients could be assisted to sit up.

1.4.2.7 Postoperative Pain Management: Pain is common after idiopathic scoliosis surgery, mostly presenting as incisional pain rather than radicular pain. Multimodal analgesia based on non-steroidal anti-inflammatory drugs was applied, with routine patient-controlled analgesia using morphine. Muscle relaxants were added when patients sat up within 3 days postoperatively. If adverse reactions were significant, medications were adjusted promptly.

1.4.2.8 Early Postoperative Rehabilitation Training: Following the principles of "active movement as primary, passive as supplementary," "gradual progression," and "not increasing pain," rehabilitation began 6–8 hours postoperatively, starting with adaptive training such as toe flexion and gradually increasing intensity. Patients were assisted to sit up with drainage tubes in place and guided through ambulation training.

1.4.2.9 Follow-up Plan: Patients and families were informed about outpatient follow-up plans after discharge, including correction effect assessment, imaging evaluation, SRS-22 questionnaires, and physical and social function assessment.

1.5 Observation Indicators Clinical data were collected and organized for enrolled patients, including gender, age, BMI, surgical segments, total length of stay, postoperative length of stay, number of postoperative transfusions, allogeneic red blood cell transfusion volume, incidence of complications within 30 days, unplanned reoperation rate, pain scores at discharge (NRS), and discharge satisfaction scores.

1.6 Statistical Processing SPSS 17.0 software was used for statistical analysis. Continuous variables were expressed as mean ± standard deviation, and categorical data were expressed as counts and percentages. Chi-square test was used to compare gender, surgical segments, 30-day complication rates, and unplanned reoperation rates between groups. Independent sample t-test was used to compare age, BMI, total length of stay, postoperative length of stay, transfusion volume, pain scores, and discharge satisfaction. A two-sided $P<0.05$ was considered statistically significant.

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2. Results

2.1 General Clinical Data The general clinical data of patients in the traditional and ERAS groups were well-matched, with no statistically significant differences in gender, age, BMI, or surgical segments (Table 2).

General Clinical Data of Adolescent Scoliosis Patients in Traditional and ERAS Groups

2.2 Clinical Outcome Indicators The total length of stay in the ERAS group was (11.35±1.49) days, significantly shorter than the traditional group' s (17.18±2.67) days (P<0.05). Postoperative length of stay was (7.19±0.71) days in the ERAS group versus (9.34±0.52) days in the traditional group (P<0.05). The number of patients requiring allogeneic transfusion in the ERAS group was significantly reduced compared to the traditional group [20% (20/100) vs 41% (41/100), P<0.05], and allogeneic red blood cell transfusion volume was also significantly lower [(0.59±0.12) U vs (1.43±0.39) U, P<0.05]. The 30-day complication rates were 3% (3/100) in the ERAS group and 6% (6/100) in the traditional group, while the 1-year unplanned reoperation rates were 2% (2/100) and 9% (9/100), respectively—neither difference reaching statistical significance. Pain scores at discharge were (3.00±0.47) in the ERAS group versus (3.40±0.63) in the traditional group, and discharge satisfaction scores were (94.86±7.92) versus (95.14±6.87), respectively, with no statistically significant differences (Table 3).

Comparison of Clinical Outcomes Between Traditional and ERAS Groups in Adolescent Scoliosis Patients

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Discussion

This study demonstrates that implementing an accelerated rehabilitation protocol during the perioperative period for adolescent scoliosis can effectively reduce total hospital stay and postoperative length of stay, decrease the number of patients requiring allogeneic transfusion and transfusion volume, and alleviate pain at discharge, all without increasing postoperative complications or unplanned reoperation rates.

Pain and blood transfusion are important factors affecting postoperative length of stay. In developed European and American countries, the postoperative hospital stay for adolescent idiopathic scoliosis is approximately 5–6 days, with about 30% of patients requiring transfusion. Previous studies have focused on addressing these two issues. However, adolescent scoliosis patients experience more severe anxiety than those with degenerative spinal diseases. Lack of understanding about treatment protocols, postoperative discomfort, gastrointestinal issues, and improper urinary catheter care can also affect recovery. Comprehensive clinical pathways addressing both preoperative and perioperative care have been shown to promote early recovery in scoliosis patients, though domestic reports in this area remain limited.

Our center has developed a comprehensive perioperative rapid rehabilitation management strategy for adolescent scoliosis based on evidence-based medicine, covering preoperative cardiopulmonary function assessment and fasting protocols, intraoperative blood and fluid management, and postoperative gastrointestinal and urinary tract management. This protocol has essentially achieved the goal of reducing stress response and accelerating postoperative recovery.

Wound healing problems also contribute to increased postoperative length of stay, often related to improper intraoperative soft tissue protection and technical issues. While improving traditional treatment methods is important, strict quality control of numerous medical behaviors and operational details throughout the treatment process is equally essential. Accelerated recovery remains the goal of medical practice, involving all aspects of treatment and guided by reducing patient stress response and the physiological, psychological, and life impacts of treatment.

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Note: Figure translations are in progress. See original paper for figures.