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Retrospective Study

Effectiveness of enhanced recovery after surgery in the perioperative management of patients with bone surgery in China

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Abstract

BACKGROUND

Enhanced recovery after surgery (ERAS) was introduced in China in 2007. Over time, the scope of ERAS has expanded from abdominal surgery to orthopedics, urology and other fields. Continuous development and research has contributed to progress of ERAS in China. In 2019, to promote the application of ERAS in bone tumor surgery, we formed the "Consensus of Experts on Perioperative Management of Accelerated Rehabilitation in Major Surgery of Bone Tumors in China".

AIM

To evaluate the effect of enhanced recovery after bone tumor surgery in perioperative management in China.

METHODS

One hundred and seven patients who underwent bone tumor surgery at the Second Affiliated Hospital of Xi'an Jiaotong University between May 2019 and April 2021 were randomized into a study group (53 cases) and a control group (54 cases). The study group adopted the ERAS protocol and the control group adopted conventional care. Main outcome measures included postoperative length of stay (LOS), postoperative complications, mortality, and 30-d readmission rates. Secondary outcomes included postoperative visual analog scale (VAS) score of pain, number of blood transfusions, drainage volume in 24 h after operation, patient satisfaction 30 d after discharge, VAS score at 30 d after discharge, and daily standing walking time.

RESULTS

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There were no significant differences in the baseline data, clinical features and surgical site between the two groups. The LOS in the study group with the ERAS protocol was 7.72 ± 3.34 d compared with 10.28 ± 4.27 d in the control group who followed conventional care. The incidence of postoperative nausea and vomiting (PONV) in the study group was 19% and 37% in the control group. The VAS scores of pain on postoperative day 1 (POD1) and POD3 in the study group were 4.79 ± 2.34 and 2.79 ± 1.53 compared with 5.28 ± 3.27 and 3.98 ± 2.27 in the control group. The drainage volume in 24 h after the operation was 124.36 ± 23.43 mL in the study group and 167.43 ± 30.87 mL in the control group. The number of blood transfusions in the study group was also lower. The patient satisfaction rate was higher in the study group than in the control group.

CONCLUSION

The ERAS protocol in the perioperative period of bone tumor surgery can decrease LOS, PONV, and postoperative pain, blood transfusion and 24-h drainage, improve patient satisfaction and accelerate recovery.

Key Words: Enhanced recovery after surgery; Bone tumor surgery; Perioperative management; Effect evaluation; Clinical application

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Core Tip: In 2019, the consensus of Chinese experts was proposed for perioperative management of accelerated rehabilitation in major surgery of bone tumors. In order to form a realistic, feasible enhanced recovery after surgery (ERAS) concept, the clinical effect of the ERAS protocol was evaluated retrospectively. The ERAS protocol can shorten hospital stay, reduce the incidence of postoperative nausea and vomiting, reduce postoperative pain, postoperative blood transfusion and postoperative 24-h drainage, and improve patient satisfaction and accelerate recovery. It is worth continuing to improve and popularize ERAS in China.

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INTRODUCTION

Enhanced recovery after surgery (ERAS) is a series of perioperative optimization measures based on evidence-based medicine that can reduce the physiological and psychological trauma stress, reduce complications, shorten the length of hospital stay (LOS), and promote postoperative rehabilitation[1]. In 2007, ERAS was introduced in China by Li[2] in the context of abdominal surgery, and since then the scope of its application has expanded to orthopedics, urology and other fields, and researchers have continued to develop and explore the applications of ERAS in China. In 2018, "the Chinese Expert Consensus and pathway management guidelines for Accelerated Rehabilitation Surgery" defined ERAS as: "based on evidence-based medicine, with the purpose of reducing the physiological and psychological trauma stress response in surgical patients, optimize the clinical pathway of perioperative management through multidisciplinary cooperation of surgery, anesthesia, nursing and nutrition, so as to reduce the perioperative stress response and postoperative complications, shorten the length of stay, and promote the recovery of patients"[3].

Patients who undergo major bone tumor surgery, perioperative management and rehabilitation are often faced with difficulties and challenges. Major surgery for bone tumor refers to operation on the spine, pelvis and limbs; in such cases, in order to obtain an ideal resection boundary, it is necessary to expose and potentially damage a wide range of anatomical areas. In addition, for patients with malignant bone tumor, previous treatments, metastasis and other factors, can lead to organ damage and

conditions such as anemia, thrombocytopenia, immunosuppression and organ dysfunction. Therefore, reducing or avoiding factors that can negatively impact the management of patients who undergo bone tumor surgery, and promote their rapid postoperative rehabilitation are important clinical priorities[4].

In 2019, in order to promote the application of the ERAS concept in bone tumor surgery, enhance the postoperative rehabilitation and improve the prognosis of patients with major bone tumor surgery, the Bone Oncology Group of the Orthopedic Branch of the Chinese Medical Association promoted discussions on this topic among a group of more than 20 national experts. Based on previous clinical experience and published relevant literature, and following the principle of evidence-based medicine a “Consensus of Experts on Perioperative Management of Accelerated Rehabilitation in Major Surgery of Bone Tumors in China” was formed[4]. The aim of this study was to evaluate the impact of the proposed consensus measures.

MATERIALS AND METHODS

Study population

This study included 107 patients undergoing bone tumor surgery between May 2019 and April 2021 at the Second Affiliated Hospital of Xi’an Jiaotong University. Patients were randomized into a study group (53 cases) and a control group (54 cases). This study was approved by the Ethics Committee of the Second Affiliated Hospital of Xi’an Jiaotong University. All patients and their families were informed of the aim of the study and gave signed informed consent.

The inclusion criteria were confirmation of bone tumor occurring in the spine (including sacrum), spine pelvis and major joints of limbs by histopathological examination, and indication for surgical treatment. The exclusion criteria were patients with cognitive impairment and mental illness; or with other malignancies and other serious systemic diseases.

A total of 156 patients were screened for eligibility, of whom 49 were excluded (29 cases did not meet the inclusion criteria, 8 refused to participate, and 12 were lost to follow-up). The remaining 107 patients were randomly divided into a study group and a control group by the order of admission following a computer-generated list of randomization codes. The study group adopted the ERAS pathway and the control group adopted conventional care (Table 1).

ERAS protocol

Our multidisciplinary ERAS working group consisted of personnel with expertise in neurosurgery, anesthesia, nursing, nutrition, physical therapy and rehabilitation. Based on the expert consensus and the current situation of our hospital, the components of ERAS were organized in three chronological sections: preoperative, intraoperative and postoperative. Our ERAS program is a comprehensive pathway of perioperative care including psychological education and intervention, nutritional status assessment and management, use of prophylactic antibiotics, anesthesia management, blood management, pain management, prevention of venous thrombosis, surgical incision and drainage, and postoperative rehabilitation exercise.

Outcome measurements

Main outcome measures included postoperative LOS, postoperative complications, mortality, and 30-d readmission rates. Postoperative complications included local and systemic complications. Local complications were defined as incision swelling, exudation, blister, infection, skin purpura around knee, gasket dislocation, infection around prosthesis. Systemic complications were defined as postoperative nausea and vomiting (PONV), drowsiness, cardiovascular adverse events, respiratory diseases, postoperative urinary retention, mental disorders, among others. Secondary outcomes were postoperative visual analog scale (VAS) score of pain, number of blood transfusions, drainage volume at 24 h after operation, patient satisfaction at 30 d after discharge, VAS score at 30 d after discharge, and daily standing walking time.

Statistical analysis

The SPSS software (version 23.0; IBM Corporation, Armonk, NY, United States) was used to conduct data analysis. The skewness coefficient, kurtosis coefficient, and normal single sample Kolmogorov-Smirnov test were used to assess normality. Data that followed a normal distribution were described as mean \pm SD, and an independent

Table 1 Enhanced recovery after major bone tumor surgery

Phase	Item	ERAS pathway	Conventional care
Preoperative	Patient and family	Detailed communication of the basic knowledge of the tumor, the purpose and method of surgery, rehabilitation process, postoperative further treatment. Requested informed consent for study participation	Routine consultation. Requested informed consent for study participation
	Patient evaluation	Preoperative KPS, pain VAS score, anxiety and depression HADS score, nutritional status NRS 2002 score, VTE Caprini Risk Assessment Scale	Preoperative KPS, pain VAS score, anxiety and depression HADS score, nutritional status NRS 2002 score, VTE Caprini Risk Assessment Scale
	Nutritional intervention	Nutritional consultation for patients with BMI < 18.5 or > 24, serum albumin level < 3.5 g/dL	Nutritional consultation as needed
	Antithromboticprophylaxis	Active/passive limb movement, plantar vein pump, intermittent air pressure device, color Doppler ultrasound screening of lower extremity vein	Active/passive limb movement, plantar vein pump, intermittent air pressure device
	Preventive analgesia	Use of opioids to reduce central and peripheral sensitivity to pain and relieve preoperative anxiety	No
	Blood management	HB raised to above 100 g/L	No
	Diet management	Liquid food 2 h before anesthesia and solid food 6 h before anesthesia for patients without aspiration risk	Fasting time for 6-8 h
Intraoperative	General anesthesia	Combined IV-inhalation anesthesia, induced with propofol sufentanil and rocuronium, and maintained with propofol, fentanyl, and sevoflurane	Combined IV-inhalation anesthesia, induced with propofol sufentanil and rocuronium, and maintained with propofol, fentanyl, and sevoflurane
	Local incisionanesthesia	Local infiltration anesthesia or intraspinal anesthesia according to patient condition	No
	Control bleeding	Selective interventional embolization and balloon occlusion of abdominal aorta; Intraoperative control of hypotension and antifibrinolytic drugs administration	Selective interventional embolization and balloon occlusion of abdominal aorta
	Pain management	Adductor block under the guidance of ultrasound during anesthesia. Drug injection into the periarticular area. Prescriptions included ropivacaine, morphine, ketorolac tromethamine, betamethasone, and norepinephrine	Opioids
	Infusion restriction	Limited infusion, rational use of colloid and crystal gel combined with intraoperative infusion	No
	ICU and extubation	Avoid admission to ICU extubate at end of surgery	Routine admission to ICU delayed extubation in ICU
Postoperative	Diet	Oral free fluids: 6 h after surgery light diet, 8 h after surgery as tolerated by the patient; semi-liquid/solid diet, 12-24 h after surgery; ordinary diet, 24-48 h after surgery	Oral liquid diet
	Infusion restriction	Daily infusion volume less than 1500 mL	No restrictions
	Pain management	Combined with selective COX-2 inhibitors, opioids, sedatives, hypnotics, and anxiolytics	Combined with selective COX-2 inhibitors
	Blood management	Elastic bandage applied to the incision of limb surgery, icing, and limb elevation	No
	Urinary catheterremoval	Early removal of urinary catheter within 24 h after surgery whenever possible	Routine removal of urinary catheter on POD 1-2
	PONV	Prevention with dexamethasone or serotonin receptor	No
	Early mobilization	In-bed mobilization, 6 h after surgery early ambulation, POD1	Routine mobilization and ambulation
Discharge	Patient assessment	Preoperative KPS, pain VAS score, anxiety and depression HADS score,	Preoperative KPS, pain VAS score, anxiety and depression HADS score Nursing satisfaction
	Other assessments	Complications, LOS	Complications, LOS
Follow-up	Patient evaluation 30d after discharge	Satisfaction, VAS, daily standing walking time	Satisfaction, VAS, daily standing walking time

BMI: Body mass index; ERAS: Enhanced recovery after surgery; KPS: Karnofsky Performance Status; VAS: Visual analog scale; HADS: Hospital Anxiety

and Depression Scale; NRS 2002: Nutritional Risk Screening 2002; VTE: Venous thromboembolism; PONV: Postoperative nausea and vomiting; ICU: Intensive care unit; POD: Postoperative day; LOS: Length of stay.

sample *t* test was used to determine statistical significance. Data that did not follow a normal distribution were described by median (P25–P45) and were analyzed using the Mann–Whitney *U* nonparametric rank-sum test and the Kruskal–Wallis test. Categorical variables were described as rate and compared between groups using a χ^2 test. $P < 0.05$ was considered statistically significant.

RESULTS

Patient characteristics

All patients completed all investigations during admission and follow-up. Baseline characteristics included age, sex, body mass index, preoperative VAS, fasting blood glucose, Karnofsky Performance Status (KPS), and anxiety and depression scores. There were 53 patients in the study group, including 34 men and 19 women. There were 54 patients in the control group, including 38 men and 16 women. The average age of the study group was 48.59 ± 5.21 years (range 22–65 years). The average age of the control group was 46.54 ± 4.86 years (range 21–62 years). There were no significant differences in baseline characteristics between the groups. Clinical data included comorbidities and the surgical site. There were no differences in the prevalence of diabetes, hypertension, chronic heart disease, liver/gallbladder disease and lung disease between the groups. Similarly, the patient distribution was also comparable in terms of site of surgery (spine, pelvis, upper limb joint, and lower limb joint) between the groups (Table 2).

Main outcome measures

A comparison of the main outcome measures after bone tumor surgery between groups was performed. The LOS was 7.72 ± 3.34 d for the study group with ERAS protocol and 10.28 ± 4.27 d for the control group with conventional care. The difference in LOS between the two groups was significant ($P = 0.00$). The incidence of PONV was 30.19% (16/53) in study group and 70.37% (38/54) in the control group ($P < 0.05$). There were no significant differences in postoperative complications and 30-d readmission between groups. No death or venous thromboembolism (VTE) events occurred in either group (Table 3).

Secondary outcome measures

A comparison of the secondary outcome measures after bone tumor surgery between groups was performed. Postoperative VAS pain scores decreased in both groups compared with the baseline data; the pain continued to subside with recovery time. However, the decrease in the pain score of the study group with ERAS Protocol was more pronounced in the study group than in the control group. The VAS scores of pain in postoperative day (POD1) and POD2 in the study group were significantly lower than those in the control group ($P = 0.00$ and 0.01). However, no significant differences between groups were observed 1 mo after discharge. The drainage volume in 24 h after the operation was 124.36 ± 23.43 mL in the study group and 167.43 ± 30.87 mL in the control group. The rate of blood transfusion was 13.21% (7/53) in the study group and 35.19% (19/54) in the control group. The difference in drainage volume ($P = 0.00$) and blood transfusion ($P = 0.00$) was significant. Patient satisfaction was evaluated according to three categories: very satisfied, satisfied and dissatisfied. For the purpose of statistical analysis, the very satisfied and satisfied categories were pooled. The satisfaction rate in study group was 84.91% (45/53), which was higher than that in the control group (32%) (Table 4).

DISCUSSION

ERAS was first proposed by Kehlet *et al*[5] in 1997. ERAS is a management mode that aims to increase patient comfort and reduce perioperative complications from the perspective of reducing stress response of surgical patients[6]. Prior research suggests that ERAS can not only accelerate patient recovery and reduce the incidence of

Table 2 Patient baseline demographics and clinical characteristics

	Study group	Control group	t/ χ^2	P value
Sex (male/female)	34/19	38/16	0.47	0.49
Age ¹ (yr)	48.59 ± 5.21 (22-65)	46.54 ± 4.86 (21-62)	2.24	0.13
BMI (kg/m ²) ²	18.73 ± 3.92	19.21 ± 4.04	0.14	0.89
Preoperative VAS ²	6.57 ± 1.08	6.61 ± 1.24	0.23	0.56
Fasting blood glucose ² (mmol/L)	6.42 ± 1.11	6.61 ± 1.67	2.89	0.07
Complication, n (%)				
Diabetes	9 (16.98)	4 (7.41)	1.49	0.22
Hypertension	35 (66.04)	27 (50.0)	2.82	0.09
Chronic heart disease	6 (11.32)	6 (11.11)	0.12	0.97
Liver/gallbladder	4 (7.55)	3 (5.56)	0.01	0.98
Lung	7 (13.21)	9 (16.67)	0.02	0.86
KPS ³	90 (60-100)	90 (70-100)	1.71	0.18
Anxiety ³	6 (1-20)	7 (2-17)	0.42	0.34
Depression ³	4 (1-18)	6 (2.18)	0.27	0.45
Surgical site				
Spine	15	16	0.61	0.89
Pelvis	7	6		
Upper limb joint	7	5		
Lower limb joint	24	27		

¹mean ± SD (range).

²mean ± SD.

³Median (P25-P75). BMI: Body mass index; VAS: Visual analog scale; KPS: Karnofsky Performance Status.

Table 3 Comparison of the main outcome measures between groups after bone tumor surgery

	Study group	Control group	t/ χ^2	P value
LOS ¹ (d)	7.72 ± 3.34	10.28 ± 4.27	23.47	0.00
Complications, n (%)				
PONV	16 (30.19)	38 (70.37)	17.28	0.00
Incision infection	8 (15.09)	14 (25.93)	1.92	0.17
Urinary tract infection	5 (9.43)	7 (12.96)	0.34	0.56
Pulmonary infection	5 (9.43)	3 (5.96)	0.58	0.45
VTE	0	0		
30-d readmission, n (%)	7 (13.21)	11 (20.37)	0.98	0.32
Death	0	0		

¹mean ± SD. LOS: Length of stay; PONV: Postoperative nausea and vomiting; VTE: Venous thromboembolism.

complications, but also reduce medical costs, shorten LOS, and increase patient satisfaction[7-9]. In recent years, ERAS has been widely used in many surgical fields including orthopedics in China[10-12].

Most patients with bone tumor surgery have anxiety and fear before operation, as confirmed in this study. Another study found that explicit preoperative psychological education and intervention can substantially relieve anxiety and emotional stress before bone surgery[13]. Preoperative education is helpful to improve patients'

Table 4 Comparison of the secondary outcome measures between two groups after bone tumor surgery

	Study group	Control group	<i>t</i> / χ^2	<i>P</i> value
VAS of POD 1 ¹	4.79 ± 2.34	5.28 ± 3.27	13.47	0.00
VAS of POD 3 ¹	2.79 ± 1.53	3.98 ± 2.27	8.23	0.01
VAS 1 mo after discharge ¹	0.88 ± 0.12	1.23 ± 0.67	2.24	0.13
Drainage volume ¹ (mL)	124.36 ± 23.43	167.43 ± 30.87	12.23	0.00
Blood transfusion, <i>n</i> (%)	7 (13.21)	19 (35.19)	7.02	0.00
Standing walking time (h) ¹	3.25 ± 3.23	2.92 ± 4.17	3.13	0.07
Satisfaction, <i>n</i>			8.72	0.00
Satisfied	45	32		
Dissatisfied	8	22		

¹mean ± SD. Visual analog scale (VAS) and of postoperative day 1 (POD 1): VAS score on the first day after operation; VAS and of POD 3: VAS score on the third day after operation. VAS: Visual analog scale; POD: Postoperative day.

confidence and satisfaction, and facilitate early rehabilitation and discharge[14].

In the study group (ERAS group), doctors tried to understand their patients' concerns and problems and were sensitive to the emotional reaction of patients. They also provided to patients and their families detailed information about the tumor, the purpose and method of the operation, the rehabilitation process, and further treatment plan and prognosis. Patients who were cured shared their own experience, which could help build overall patient confidence in rehabilitation. At the same time, the family members of patients were more enlightened and concerned about patients. Through preoperative psychological education and intervention, we can form a trust relationship among patients, family members and medical staff, so that patients can maintain an optimistic attitude and the confidence to overcome the disease.

Malnutrition and low serum protein levels are independent risk factors for postoperative complications. Therefore, nutritional risk screening and assessment should be carried out before major surgery for bone tumors[15,16]. About 27% of orthopedic patients have different degrees of hypoproteinemia, which is positively correlated with age[17]. Even in some bone tumor patients with good preoperative nutritional status, due to the large amount of intraoperative blood loss or decreased postoperative food intake and other factors, their nutritional indicators may also decline significantly. For patients with definite malnutrition, oral immunonutrition supplement can be preferred and used continuously for 5–7 d preoperatively. Preoperative parenteral nutrition therapy is only suitable for patients with severe malnutrition risk and enteral nutrition cannot meet their needs. Standard whole protein formula is recommended for postoperative nutrition[18]. Surgical site infection, in particular deep tissue infection, is a serious complication that can lead to failure of bone tumor surgery[19]. Therefore, prophylactic use of antibiotics should be carried out before the operation. The consensus is that preoperative fasting time of general anesthesia should be 6–8 h, which may lead to discomfort and increased insulin resistance and protein breakdown. Therefore, patients without aspiration risk are given liquid food 2 h before and solid food 6 h before anesthesia[20]. Preoperative anemia is also an independent risk factor for postoperative complications and death. Therefore, anemia screening should be performed, and patients should have hemoglobin > 100 g/L[21]. Compared with other operations, bone tumor surgery is often more traumatic, and can result in more pain and more severe stress responses. Therefore, personalized analgesia, preventive analgesia and multimodal analgesia should be considered. Pain relief in our study group with ERAS protocol was more pronounced than that in the control group. The combination of different postoperative analgesic methods not only improves the effect of perioperative pain relief, but also allows single drug dose reduction and helps minimize toxic and adverse effects. Sleep and anxiety can be further improved and pain relief can be alleviated by including hypnotic and sedative approaches.

Currently, understanding of early mobilization is limited because patients with postoperative complications and pain are unable to complete early postoperative activities, and it is there controversial whether early mobilization is an exposure factor or a result. In the ERAS group, the drainage tube was pulled out 24 h after the

operation, which facilitated early mobilization and early ambulation, and helped accelerate patient recovery. Adequate pain control is also important for early mobilization and early ambulation.

In this study, the mean LOS in the study group was 7.72 d compared to 10.28 d in the control group. Related studies in China have reported that the average LOS under the ERAS concept was 10 d, with a median of 8 d. In contrast, the average LOS in the control group was 18 d, with a median of 13 d[22]. In other countries, the average LOS of patients with ERAS was shorter than in China, and was 5-6 d[23,24]. However, about 50%-80% of the discharged patients in developed countries are taken out of hospital care institutions[25], which might help explain this differences between countries. Therefore, the readmission rate of discharged patients after surgery and the factors influencing readmission LOS warrant further investigation. In this study, the incidence of PONV, postoperative 24-h blood drainage and postoperative blood transfusion in the ERAS group were better than those in the conventional treatment group. No VTE or death occurred during the perioperative period in either of the groups. However, there were no significant differences in postoperative complications such as incision infection, urinary tract infection and pulmonary infection caused by long-term bed rest; understanding the reasons for this lack of improvement in the study group require further investigation.

Our study also had some limitations. The follow-up time was short and the patient sample size was small. There was some heterogeneity regarding the sites of surgery (four sites). All these factors might influence the results, and therefore a better control for confounding is needed in future studies. In addition, because ERAS provides more detailed and personalized services to patients, it requires higher quality of medical staff and the need for more allocated doctor's time. In China, there are still many difficulties in the application and promotion of ERAS given insufficient number and uneven quality of medical staff. Further research is needed to design a more concise, easier to understand, and more efficient ERAS protocol to be implemented in China.

CONCLUSION

The application of ERAS in the perioperative period of bone tumor surgery can shorten the duration of hospital stay, and reduce the incidence of PONV, postoperative pain, and the need for postoperative blood transfusion and postoperative 24-h drainage. ERAS has the potential to improve patient satisfaction and accelerate recovery. Further improvements and promotion of ERAS in the context of bone surgery are warranted.

ARTICLE HIGHLIGHTS

Research background

Enhanced recovery after surgery (ERAS) has gradually been applied and promoted in various clinical disciplines in China.

Research motivation

This research attempted to propose appropriate ERAS protocol for patients with bone surgery in the perioperative management in China.

Research objectives

This study aimed to evaluate the clinical application of the Consensus of Experts on Perioperative Management of accelerated rehabilitation in major surgery of Bone Tumors in China.

Research methods

A total of 107 patients undergoing bone tumor surgery were randomized into a study group (53 cases) and control group (54 cases). Retrospective analysis was used to measure the nursing effect of two groups of patients with different nursing measures.

Research results

ERAS protocol can shorten the postoperative hospital stay of patients with bone tumors, reduce the incidence of postoperative nausea and vomiting, reduce

postoperative pain, reduce postoperative blood transfusion and postoperative 24-h drainage, improve patient satisfaction and accelerate rehabilitation.

Research conclusions

ERAS protocol is worth popularizing in the perioperative period of Chinese patients with bone tumors.

Research perspectives

Assessing the effectiveness of measures with practical results.

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