Impacts of Average Real Variability Parameters of Blood Pressure on Recovery Following Posterior Fixation Surgery for Thoracolumbar Vertebral Fractures

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Guanyi He[1], Nan Yu[1], Rui Huang[1], Yingzhe Jin[1], Ming Yao[1], Shuo Wang[2], Huibin Zhang[1]

[1]Department of Trauma Surgery, Ningbo Medical Center Lihuili Hospital, 315000 Ningbo, Zhejiang, China
[2]Department of Otorhinolaryngology, Ningbo Beilun Third People's Hospital, 315801 Ningbo, Zhejiang, China

AIM: This study aimed to investigate the influence of average real variability (ARV) parameters of blood pressure on the recovery following posterior fixation surgery for thoracolumbar vertebral fractures.

METHODS: A retrospective analysis was conducted on 190 patients who underwent posterior fixation surgery for thoracolumbar vertebral fractures at Ningbo Medical Center Lihuili Hospital between January 2021 and December 2023. Patients were divided into two groups based on their postoperative recovery: the good recovery group (n = 140) and the poor recovery group (n = 50). Univariate and binary logistic regression analyses were performed to identify factors influencing postoperative recovery. Pearson correlation analysis was used to assess the relationships between ARV and other variables, while receiver operating characteristic (ROC) curve analysis was conducted to evaluate the predictive value of ARV in postoperative recovery.

RESULTS: No statistically significant differences were observed between the two groups in terms of age, body mass index (BMI), gender, place of residence, monthly family income, occupation, education level, surgery duration, intraoperative blood loss, fracture type, fracture location, or fracture stage ($p > 0.05$). However, significant differences were noted in complication rates, ARV levels, and self-efficacy scores ($p < 0.05$). Pearson linear correlation analysis revealed that ARV was positively correlated with the presence of complications ($r = 0.151$, $p < 0.05$). Binary logistic regression analysis identified complications, ARV, and self-efficacy as significant factors influencing postoperative recovery ($p < 0.05$). Patients were divided into four groups based on ARV quartiles: Group 1 (ARV < 0.79), Group 2 ($0.79 \leq$ ARV < 0.89), Group 3 ($0.89 \leq$ ARV < 0.98), and Group 4 (ARV ≥ 0.98). A statistically significant difference in complication rates was observed across the groups ($p < 0.05$). ROC analysis showed that the area under the curve (AUC) for ARV in predicting postoperative recovery was 0.724 (95% confidence interval (CI): 0.612–0.836, $p < 0.001$).

CONCLUSIONS: ARV is a significant factor influencing recovery following posterior fixation surgery for thoracolumbar vertebral fractures. Higher ARV levels are associated with increased postoperative complications, leading to poorer recovery outcomes.

Keywords: average real variability; posterior fixation surgery; thoracolumbar vertebral fracture; postoperative recovery

Introduction

Posterior fixation surgery is widely employed to treat thoracolumbar vertebral fractures, stabilizing the fracture site to promote bone healing and help patients recover spinal function [1,2]. Despite significant advancements in surgical techniques, significant individual variability in postoperative recovery persists among patients with thoracolumbar vertebral fractures [3]. In recent years, an increasing number of studies have focused on the impacts of various physiological parameters during surgery on postoperative recovery [4,5]. One such factor is blood pressure variability (BPV), which reflects the degree of fluctuation in blood pressure over a defined period [6]. Elevated average real variability (ARV) in blood pressure can increase shear forces on the vessel walls, leading to vascular damage, the development of atherosclerosis, and potentially impairing postoperative recovery [7]. In thoracolumbar vertebral fracture surgery, multiple factors, like surgical trauma, anesthetic drug effects, and the patient's underlying pathophysiological state, may contribute to significant intraoperative ARV [8]. Marked fluctuations in intraoperative blood pressure may significantly impact surgical outcomes, the incidence of postoperative complications, and overall recovery.

This study aimed to investigate the impact of ARV parameters on recovery following posterior fixation surgery for thoracolumbar vertebral fractures. The purpose was to optimize anesthetic management, mitigate the risk of postoperative complications, and improve patients' postoperative quality of life.

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Correspondence to: Huibin Zhang, Department of Trauma Surgery, Ningbo Medical Center Lihuili Hospital, 315000 Ningbo, Zhejiang, China (e-mail: lhlyycsgk@126.com).

Materials and Methods

Research Subjects

A retrospective analysis was conducted on 190 patients treated for thoracolumbar vertebral fractures at Ningbo Medical Center Lihuili Hospital between January 2021 and December 2023. Patients were divided into two groups based on postoperative recovery: the good recovery group (n = 140) and the poor recovery group (n = 50). The grouping process is illustrated in Fig. 1. The inclusion criteria were as follows: (1) Patients meeting the diagnostic criteria for thoracolumbar vertebral fractures; (2) Diagnosis confirmed by X-ray, computed tomography (CT) scans, or other diagnostic methods; (3) Patients meeting surgical indications and undergoing posterior fixation surgery at Ningbo Medical Center Lihuili Hospital; (4) Patients admitted for treatment within 24 hours of injury.

The exclusion criteria were as follows: (1) Patients with osteoporosis; (2) Patients with pathological fractures, old fractures, or multi-segment fractures; (3) Patients with cognitive or mental disorders; (4) Patients with systemic infections; (5) Patients with severe cardiopulmonary insufficiency.

Research Methods

Criteria for Postoperative Recovery Assessment

Three months postoperatively, lumbar spine function of the patients was assessed using the Japanese Orthopaedic Association (JOA) scoring system [9]. This evaluation includes three domains, with a total score ranging from 0 to 29 points, where higher scores indicate better lumbar spine function. Based on the degree of improvement in JOA scores compared to pre-treatment levels, patients were classified into two groups. Patients with an improvement exceeding >90% were categorized as "Excellent", while those with improvements between 70% and 90% were categorized as "Good", and those with improvements between 40% and 70% were considered "Fair". Patients in the "Excellent", "Good", or "Fair" categories were considered to have good recovery of lumbar spine function and were included in the good recovery group. Patients with less than 40% improvement in JOA scores compared to pre-treatment levels were considered to have poor recovery of lumbar spine function and were assigned to the poor recovery group (n = 50).

Measurement of Blood Pressure Variability

Systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP) data were collected from the department's anesthesia system database to ensure the authenticity and completeness of the data (Blood pressure readings were recorded before surgery, every 30 minutes during surgery, and at the end of surgery). Handling of outliers: Abnormal values resulting from measurement errors or device malfunctions were removed. The criteria for outlier removal included DBP ≤25 mmHg, DBP ≥220 mmHg, SBP ≤ DBP + 10 mmHg. Average real variability (ARV) [10] was calculated using the following formula: $ARV = \frac{1}{T}\sum_{k=1}^{n-1} | BP_{k+1} - BP_k | \text{ mmHg/min}$, where n represents the number of blood pressure (BP), BP is the MAP, and T is the time interval between each pair of readings in a group.

Self-Efficacy Judgment Criteria

The General Self-Effectiveness Scale (GSES) [11] was used to assess self-efficacy. The scale consists of 10 items, each scored from 1 to 4 points. A total score of ≤20 indicates low self-efficacy, while a score above 20 indicates good self-efficacy.

Complications and Underlying Conditions

Complications included underlying diseases such as diabetes.

Data Processing

Missing data were handled using interpolation and multiple imputation techniques to reduce their impact on study results. Abnormal values were processed through deletion to maintain data integrity.

Surgical Method

A median longitudinal incision was made at the affected vertebra. The fascia and underlying tissues were incised layer by layer to fully expose the vertebral articular processes. Intraoperative fluoroscopy was performed using a C-arm X-ray machine to confirm the condition of the lesion and guide the selection of appropriate pedicle screws for implantation. The connecting rod was securely positioned along the muscle gap, and adjustments were made to open or compress the injured vertebra, depending on its position. A second C-arm X-ray was performed to verify the correct placement of the screws and connecting rod. After confirming the expected position, nuts were tightened, the surgical incision was thoroughly flushed, and a drainage tube was properly placed. The incision was then sutured and bandaged according to routine procedures.

Statistical Analysis

The collected experimental data were analyzed using SPSS 27.0 (International Business Machines Corporation, Armonk, NY, USA). The Shapiro-Wilk test was applied to test normality. Metric data conforming to a normal distribution were expressed as mean ± standard deviation ($\bar{x} \pm$ s). Independent sample *t*-tests were used for group comparisons. Categorical data were presented as frequencies or rates, with comparisons conducted using the χ^2 test or Fisher's exact test. Univariate and binary logistic regression analyses were performed to identify factors influencing recovery in patients with thoracolumbar vertebral frac-

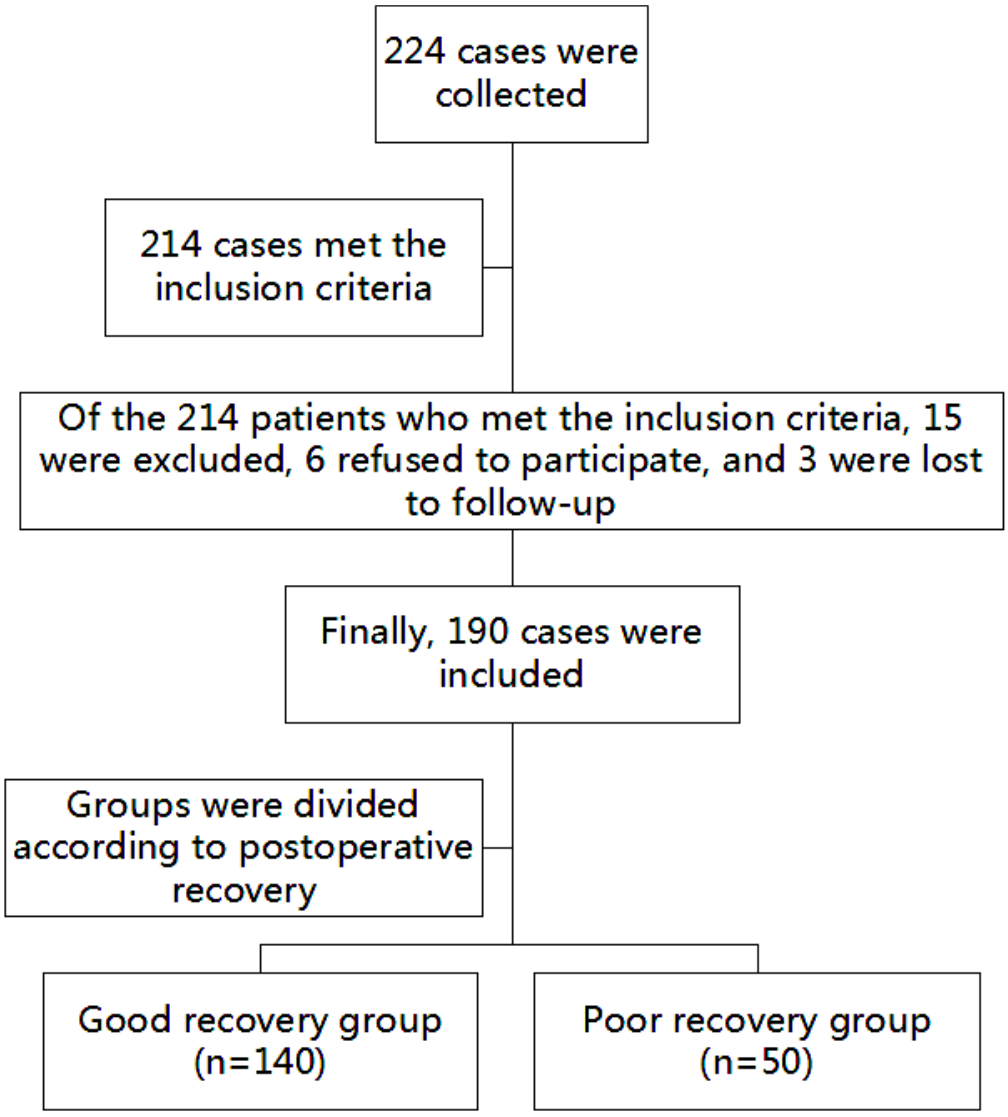

Fig. 1. Flowchart of study.

tures following posterior fixation surgery. Pearson correlation analysis was employed to assess the relationships between variables. Receiver operating characteristic (ROC) curve analysis was used to evaluate the predictive value of ARV in postoperative recovery after posterior fixation for thoracolumbar fractures. A p-value < 0.05 was considered statistically significant.

Results

Univariate Analysis of Factors Influencing Recovery in Patients With Thoracolumbar Vertebral Fractures Following Posterior Fixation Surgery

A comparison of demographic and clinical variables between the good recovery group and the poor recovery group revealed no statistically significant differences in age, body mass index (BMI), gender, place of residence, monthly family income, occupation, education level, surgery duration, intraoperative blood loss, fracture type, fracture location, or fracture stage ($p > 0.05$). However, comorbiditys, ARV of blood pressure, and self-efficacy showed statistically significant differences between the two groups ($p < 0.05$, Table 1).

Correlation Analysis

Pearson linear correlation analysis showed a positive correlation between ARV and the presence of comorbiditys (r = 0.151, $p < 0.05$, Table 2). These findings suggest that higher ARV values were associated with a greater likelihood of postoperative comorbiditys.

Binary Logistics Regression Analysis

A binary logistic regression was performed with comorbiditys, ARV, and self-efficacy as independent variables and postoperative recovery (poor = 1, good = 0) as the dependent variable. The results indicated that comorbiditys, ARV, and self-efficacy were significant factors influenc-

Table 1. Univariate analysis of factors influencing recovery of patients with thoracolumbar vertebral fractures following posterior fixation surgery.

Baseline data		Good recovery group (n = 140)	Poor recovery group (n = 50)	t/χ^2 value	*p*-value
Age ($\bar{x} \pm$ s, years)		47.34 ± 3.84	48.40 ± 4.40	1.611	0.109
BMI ($\bar{x} \pm$ s, kg/m^2)		20.94 ± 1.73	20.77 ± 1.70	0.599	0.550
Gender	Male	72	26	0.005	0.945
	Female	68	24		
Place of residence	Urban	120	44	0.163	0.686
	Rural	20	6		
Monthly income (USD)	<961.12	49	18	0.016	0.899
	≥961.12	91	32		
Occupation	Employed	94	36	0.402	0.526
	Unemployed	46	14		
Education level	Below college	42	16	0.069	0.792
	Above college	98	34		
Surgery duration ($\bar{x} \pm$ s, min)		83.01 ± 1.69	82.76 ± 1.83	0.878	0.381
Intraoperative blood loss ($\bar{x} \pm$ s, mL)		84.84 ± 2.04	84.49 ± 2.05	1.040	0.300
Comorbiditys	<2	123	33	11.979	0.001
	≥2	17	17		
Fracture type	Fracture type	25	7	0.415	0.813
	Compression fracture	36	14		
	Displaced fracture	79	29		
Fracture location	Thoracic vertebrae	71	25	0.008	0.931
	Lumbar vertebrae	69	25		
Fracture stage	L1 or L2	69	25	0.008	0.931
	T11 or T12	71	25		
ARV		0.86 ± 0.09	1.19 ± 0.43	8.608	<0.001
Self-efficacy	Low	34	25	11.378	0.001
	Good	106	25		
Time from injury to surgery (days)	<7	82	35	2.034	0.154
	≥7	58	15		

Note: BMI, body mass index; ARV, average real variability; USD, United States Dollar.

Table 2. Correlation analysis of comorbiditys, self-efficacy, and ARV.

		Comorbiditys	Self-efficacy	ARV
Comorbidity	*r*	1	0.102	0.151
	p	-	0.161	0.037
Self-efficacy	*r*	0.102	1	0.058
	p	0.161	-	0.427
ARV	*r*	0.151	0.058	1
	p	0.037	0.427	-

Table 3. Variable assignment for logistic regression analysis.

Factor	Assignment
Comorbiditys	<2 = 0, ≥2 = 1
ARV	Original value
Self-efficacy	Good = 0, Low = 1

ing postoperative recovery in patients undergoing posterior fixation surgery for thoracolumbar vertebral fractures ($p < 0.05$, Tables 3,4).

Occurrence of Complications in Patients With Different ARV Values

Patients were divided into four groups based on ARV quartiles: Group 1 (ARV <0.79), Group 2 (0.79 ≤ ARV < 0.89), Group 3 (0.89 ≤ ARV < 0.98), and Group 4 (ARV ≥0.98). A comparison of complication occurrence among these groups revealed statistically significant differences ($p < 0.05$), with the highest incidence of complications (12.50%) observed in Group 4, suggesting a potential association between higher ARV and poor postoperative outcomes (Table 5).

ROC Curve Analysis

Receiver operating characteristic (ROC) curve analysis was conducted to evaluate the predictive ability of ARV for postoperative recovery. The area under the curve (AUC) was 0.724 (95% confidence interval (CI): 0.612–0.836, $p < 0.001$), with a standard error of 0.057 and a Youden in-

Table 4. Binary logistics regression analysis of factors influencing postoperative recovery.

Variable	B	Standard error	Wald	*p*-value	Exp (B)	95% CI	
						Lower limit	Upper limit
Comorbiditys	1.157	0.487	5.651	0.017	3.179	1.225	8.250
Self-efficacy	1.252	0.423	8.739	0.003	3.496	1.525	8.016
ARV	0.517	0.101	26.163	<0.001	1.677	1.376	2.045
Constant	–6.760	1.028	43.229	<0.001	0.001	-	-

Note: CI, confidence interval.

Table 5. Occurrence of complications in patients with different ARV values (%).

Group	Number of patients	Wound infection	Urinary tract infection	Abdominal distension	Constipation	Incidence rate
1	51	0	0	0	0	0.00
2	41	0	0	1	0	2.44
3	50	0	1	1	1	6.00
4	48	1	1	2	2	12.50
χ^2 value						8.487
p-value						0.037

dex of 0.62. The optimal cut-off value for ARV was 1.01, with a sensitivity of 62.00% and a specificity of 100.00% (Fig. 2).

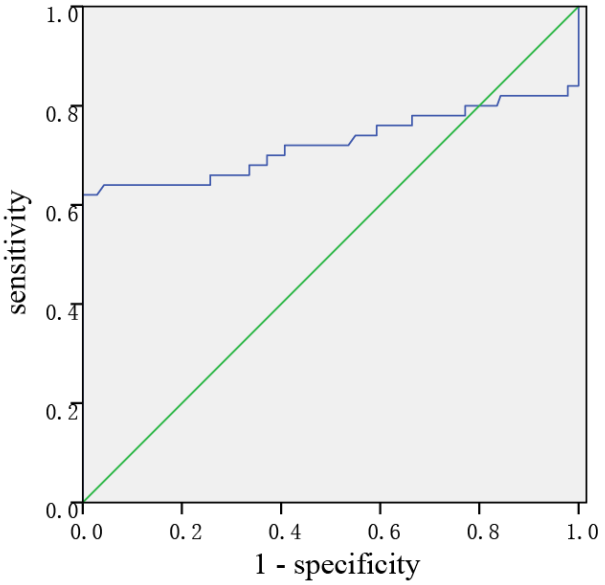

Fig. 2. Receiver operating characteristic (ROC) curve for ARV.

Discussion

The results of this study suggest that ARV, complications, and self-efficacy are important factors affecting the postoperative recovery of patients undergoing posterior fixation for thoracolumbar vertebral fractures. Notably, ARV was closely associated with the occurrence of postoperative complications, underscoring its clinical relevance.

ARV refers to the degree of fluctuation in blood pressure during surgery and serves as an indicator of cardiovascular stability. This study observed that ARV is a significant factor affecting the recovery of patients undergoing posterior fixation surgery for thoracolumbar vertebral fractures. Specifically, patients in the poor recovery group exhibited significantly higher ARV values compared to those in the good recovery group. The impacts of ARV on postoperative recovery likely involve multiple mechanisms. Firstly, significant fluctuations in intraoperative blood pressure may impose additional strain on the cardiovascular system, increasing cardiac workload and potentially leading to myocardial damage or heart failure. Hirsch *et al*. [12] previously demonstrated that fluctuations in intraoperative blood pressure adversely affect postoperative recovery, aligning with the present findings. Secondly, blood pressure fluctuations could impact blood supply to the surgical site, impairing fracture healing and tissue repair. In this study, patients with elevated ARV values were more prone to developing postoperative complications such as infections and thrombosis, further complicating postoperative recovery.

Complications emerged as another critical factor influencing postoperative recovery in patients with thoracolumbar vertebral fractures. The occurrence rate of complications was significantly higher in the poor recovery group, suggesting that complications contribute to recovery difficulties. This observation is consistent with the findings of Wang *et al*. [13], who also indicated that complications affect the postoperative recovery of thoracolumbar vertebral fracture patients. The impacts of complications on postoperative recovery manifest in several ways. Firstly, complications may increase the risk and complexity of surgery, making the surgical process more challenging and postoperative recovery slower [14]. Secondly, complications may compromise the overall health status of patients, reducing their physiological tolerance to surgery and anesthesia,

thus increasing the likelihood of postoperative complications [15]. Additionally, complications may negatively influence the patient's psychological state and willingness to engage in rehabilitation, subsequently affecting the enthusiasm and effectiveness of postoperative recovery [3,5]. The positive correlation between ARV and complications observed in this study suggests a potential synergistic effect, wherein elevated ARV may predispose patients to complications, further delaying postoperative recovery. Therefore, it is crucial to emphasize monitoring and managing intraoperative blood pressure for patients with complications to reduce ARV, mitigate postoperative complications, and promote optimal recovery.

Furthermore, this study demonstrates that self-efficacy is a crucial factor influencing the recovery of patients undergoing posterior fixation surgery for thoracolumbar vertebral fractures. Self-efficacy, defined as an individual's belief in their confidence and ability to accomplish tasks and achieve goals. Specifically, patients in the good recovery group exhibited significantly higher levels of self-efficacy compared to those in the poor recovery group, suggesting that greater self-efficacy may facilitate smoother and faster postoperative recovery. The positive impact of self-efficacy on postoperative outcomes is evident in several aspects. Firstly, enhanced self-efficacy can boost patients' confidence in surgery and rehabilitation, encouraging active participation in postoperative recovery and improving rehabilitation outcomes [1,16]. Secondly, patients with higher self-efficacy are better able to cope with postoperative pain and discomfort, reducing anxiety, fear, and other negative emotions, thereby enhancing their quality of life. Additionally, increased self-efficacy promotes communication and cooperation between patients and healthcare providers, leading to more personalized and effective rehabilitation plans.

Although self-efficacy did not show a significant correlation with ARV or postoperative complications in this study, its influence on postoperative recovery remains substantial. Therefore, during the postoperative rehabilitation process, it is essential to implement strategies aimed at cultivating patients' self-efficacy. This can be achieved through psychological counseling, rehabilitation education, and social support to enhance patients' self-efficacy, ultimately fostering postoperative recovery.

The predictive ability of ARV for postoperative recovery was another significant finding of this study. ROC analysis showed that the area under the prediction curve for ARV was 0.724, suggesting good predictive accuracy (with an AUC range of 0.7 to 0.8, generally considered acceptable for clinical prediction models). The 95% confidence interval (CI) ranged from 0.612 to 0.836, with a p-value $<$ 0.001, indicating that the prediction was statistically significant. Sensitivity and specificity are key indicators for assessing the effectiveness of predictive indicators. In this study, when the optimal ARV cutoff value was set at 1.01, the sensitivity reached 62.00%, indicating that this indicator could correctly identify 62% of patients with poor postoperative, while the specificity was 100.00%, indicating that this marker accurately ruled out the risk of complications in patients with good recovery.

The ROC curve analysis holds significant clinical implications. It provides a practical tool to determine ARV cutoffs that balance sensitivity and specificity, thereby supporting informed clinical decision-making. For example, when the ARV value exceeds 1.01, clinicians may consider the patient at a high-risk state for postoperative complications and adjust perioperative management strategies accordingly. This predictive capability offers valuable reference and guidance for optimizing surgical and aesthetic care, reducing postoperative complications, and improving patients' postoperative quality of life.

To further investigate the impact of ARV on postoperative recovery, this study categorized patients into four groups based on ARV quartiles and compared the differences in the occurrence of complications among the groups. The results indicated that special attention should be given to patients with ARV $>$0.89, with corresponding intervention strategies to mitigate blood pressure fluctuations. Especially for patients with ARV $>$0.98, close monitoring and management of intraoperative blood pressure are essential. This finding further confirms the adverse impact of ARV on postoperative recovery. Large fluctuations in blood pressure among patients with high ARV pose significant challenges to multiple physiological systems, including cardiovascular, neurological, and respiratory systems. From a cardiovascular perspective, instability in blood pressure may lead to increased cardiac load, elevating the risk of arrhythmia, myocardial ischemia, and impaired cardiac function, ultimately delaying the recovery of postoperative cardiovascular function. The nervous system may also be compromised, as sudden changes in blood pressure could result in insufficient or cerebral perfusion, damaging brain cell function and potentially leading to sequelae such as cognitive impairment or hemiplegia. Additionally, the respiratory system may be affected by hemodynamic changes caused by fluctuations in blood pressure, increasing pulmonary burden on the lungs and the risk of complications such as pulmonary edema and respiratory failure, affecting the recovery of respiratory function. These complications increase patient suffering, significantly increase medical expenses, and extend rehabilitation cycles. The mechanisms underlying these complications may be related to vascular endothelial damage, intensified inflammatory responses, enhanced oxidative stress and autonomic nervous dysfunction induced by blood pressure fluctuations. After the vascular endothelium is damaged, it is more likely to form thrombus, accelerate atherosclerosis, and further deteriorate cardiovascular conditions. Inflammatory and oxidative stress responses may intensify tissue damage and delay healing, while autonomic nervous dysfunction contributes to impaired blood pressure regulation, forming a vicious

cycle that complicates postoperative recovery. These findings highlight the importance of minimizing intraoperative blood pressure variability to reduce these adverse physiological effects.

The results of this study hold significant importance for guiding clinical practices and future research directions. First, this study reveals the unfavorable impact of ARV on the postoperative recovery of patients undergoing posterior fixation surgery for thoracolumbar vertebral fractures. This underscores the need for healthcare professionals to closely monitor blood pressure fluctuations during surgery and promptly implement strategies to reduce ARV to decrease the incidence of postoperative complications. Additionally, the study identifies complications and self-efficacy as important factors influencing postoperative recovery, suggesting that postoperative rehabilitation should consider patients' physical health status and psychological well-being, emphasizing the need for personalized rehabilitation plans. Future research should further explore the intrinsic connections between ARV and physiological parameters, such as heart rate variability and respiratory variability, as well as their collective impact on postoperative recovery. By analyzing the dynamic changes of ARV and these parameters at different time points, researchers may reveal how they synergistically affect postoperative physiological homeostasis. At the same time, it is essential to examine the specific effects of different anesthesia strategies, surgical techniques, and other perioperative factors on ARV. Optimizing anesthesia management and surgical operations could effectively reduce ARV and accelerate the postoperative rehabilitation. Additionally, large-scale, multi-center clinical studies are crucial to verify the reliability and generalizability of these findings, establishing ARV as a reliable indicator of postoperative recovery quality assessment and providing a solid scientific basis to promote the overall improvement of perioperative management practices.

Despite the significant insights on the impact of ARV on recovery after posterior fixation for thoracolumbar fractures provided by this study, there are still some limitations. Firstly, as a retrospective analysis, the collection of patient data relied on previous medical records, which may introduce incomplete information or recording biases, potentially impacting the results of this study. Secondly, although the sample size met statistical requirements, expanding the sample size in future research could enhance the representativeness and robustness of the findings. Therefore, future research should comprehensively consider more relevant factors and adopt a prospective design to more accurately assess the impact of ARV on postoperative recovery of thoracolumbar fractures and provide a more reliable foundation for clinical decision-making.

Conclusions

In conclusion, this study identifies ARV as a significant factor influencing the recovery of patients undergoing posterior fixation surgery for thoracolumbar vertebral fractures. Patients with higher ARV values were likely to experience postoperative complications, contributing to poorer postoperative recovery outcomes. These findings underscore the importance of closely monitoring intraoperative blood pressure fluctuations and implementing timely interventions to reduce ARV, thereby minimizing the incidence of postoperative complications and promoting postoperative recovery. Furthermore, a comprehensive approach to postoperative care is crucial. This includes considering patients' overall health status and psychological well-being, developing personalized rehabilitation plans, and fostering strategies to enhance self-efficacy. Such measures are critical for improving postoperative recovery outcomes and optimizing quality of life following surgery.

Availability of Data and Materials

The data used to support the findings of this study are available from the corresponding author upon request.

Author Contributions

GYH and HBZ designed the research study. GYH wrote the manuscript. GYH and SW performed the research. NY, RH, YZJ and MY analyzed the data. All authors have been involved in revising it critically for important intellectual content. All authors gave final approval of the version to be published. All authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

Ethics Approval and Consent to Participate

This study is in accordance with the Declaration of Helsinki. The study was approved by the Medical Ethics Committee of the Ningbo Medical Center Lihuili Hospital (KY2024SL493-01). The principle of informed consent was followed throughout the experiment, and information about the study was provided to patients or their families, and consent was obtained.

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Conflict of Interest

The authors declare no conflict of interest.

References

[1] Alimohammadi E, Bagheri SR, Joseph B, Sharifi H, Shokri B, Khodadadi L. Analysis of factors associated with the failure of treatment in thoracolumbar burst fractures treated with short-segment posterior spinal fixation. Journal of Orthopaedic Surgery and Research. 2023; 18: 690. https://doi.org/10.1186/s13018-023-04190-w.

[2] Hou J, Ren D, Chen Y, Geng L, Yao S, Wu H, *et al*. Effectiveness of the Endplate Reduction Technique Combined With Bone Grafting for the Treatment of Thoracolumbar Fractures by Using Posterior Short-Segment Fixation. Neurospine. 2023; 20: 353–364. https://doi.org/10.14245/ns.2244980.490.

[3] Khaledian N, Bagheri SR, Sharifi H, Alimohammadi E. The efficacy of machine learning models in forecasting treatment failure in thoracolumbar burst fractures treated with short-segment posterior spinal fixation. Journal of Orthopaedic Surgery and Research. 2024; 19: 211. https://doi.org/10.1186/s13018-024-04690-3.

[4] Xu Y, Dunn TC, Bergenstal RM, Cheng A, Dabiri Y, Ajjan RA. Time in Range, Time in Tight Range, and Average Glucose Relationships Are Modulated by Glycemic Variability: Identification of a Glucose Distribution Model Connecting Glycemic Parameters Using Real-World Data. Diabetes Technology & Therapeutics. 2024; 26: 467–477. https://doi.org/10.1089/dia.2023.0564.

[5] Yuan W, Liu X, Cong L, Zhu H, Cui C, Pei L, *et al*. Robot-assisted versus traditional fluoroscopy-assisted posterior fixation in treatment of thoracolumbar fractures with ankylosing spondylitis: a retrospective study. Zhongguo xiu fu Chong Jian wai ke za zhi = Zhongguo Xiufu Chongjian Waike Zazhi = Chinese Journal of Reparative and Reconstructive Surgery. 2024; 38: 929–934.

[6] Mulè G, Calcaterra I, Costanzo M, Morreale M, D'Ignoto F, Castiglia A, *et al*. Average real variability of 24-h systolic blood pressure is associated with microalbuminuria in patients with primary hypertension. Journal of Human Hypertension. 2016; 30: 164–170. https://doi.org/10.1038/jhh.2015.66.

[7] Mena LJ, Felix VG, Melgarejo JD, Maestre GE. 24-Hour Blood Pressure Variability Assessed by Average Real Variability: A Systematic Review and Meta-Analysis. Journal of the American Heart Association. 2017; 6: e006895. https://doi.org/10.1161/JAHA.117.006895.

[8] Coccina F, Pierdomenico AM, Cuccurullo C, Pierdomenico SD. Prognostic value of average real variability of systolic blood pressure in elderly treated hypertensive patients. Blood Pressure Monitoring. 2019; 24: 179–184. https://doi.org/10.1097/MBP.0000000000000381.

[9] Kuribayashi M, Takahashi KA, Fujioka M, Ueshima K, Inoue S, Kubo T. Reliability and validity of the Japanese Orthopaedic Association hip score. Journal of Orthopaedic Science: Official Journal of the Japanese Orthopaedic Association. 2010; 15: 452–458. https://doi.org/10.1007/s00776-010-1490-0.

[10] Mascha EJ, Yang D, Weiss S, Sessler DI. Intraoperative Mean Arterial Pressure Variability and 30-day Mortality in Patients Having Noncardiac Surgery. Anesthesiology. 2015; 123: 79–91. https://doi.org/10.1097/ALN.0000000000000686.

[11] Bosscher RJ, Smit JH. Confirmatory factor analysis of the General Self-Efficacy Scale. Behaviour Research and Therapy. 1998; 36: 339–343. https://doi.org/10.1016/s0005-7967(98)00025-4.

[12] Hirsch J, DePalma G, Tsai TT, Sands LP, Leung JM. Impact of intraoperative hypotension and blood pressure fluctuations on early postoperative delirium after non-cardiac surgery. British Journal of Anaesthesia. 2015; 115: 418–426. https://doi.org/10.1093/bja/aeu458.

[13] Wang R, Xu Y, Ma X. Risk factors and strategies for recovery quality, postoperative pain, and recurrent fractures between percutaneous kyphoplasty and percutaneous vertebroplasty in elderly patients with thoracolumbar compression fractures: a retrospective comparative cohort study. Annals of Translational Medicine. 2023; 11: 122. https://doi.org/10.21037/atm-22-6475.

[14] Wang T, Sun J, Gu D, Shen S, Zhou Y, Wang Z. Dyadic effects of social support, illness uncertainty on anxiety and depression among lung cancer patients and their caregivers: a cross-sectional study. Supportive Care in Cancer: Official Journal of the Multinational Association of Supportive Care in Cancer. 2023; 31: 402. https://doi.org/10.1007/s00520-023-07876-3.

[15] Uzunoğlu H, Kaya S. Factors Affecting Postoperative Early-term Mortality and Anastomotic Leakage in Geriatric Colorectal Cancer Patients. Annali Italiani di Chirurgia. 2024; 95: 678–689. https://doi.org/10.62713/aic.3264.

[16] Cheng P, Ying F, Li Y. Effects of Different Concentrations of Ropivacaine Lumbar Plexus-Sciatic Nerve Block on Recovery from Anesthesia, Postoperative Pain and Cognitive Function in Elderly Patients with Femoral Neck Fracture. Evidence-based Complementary and Alternative Medicine: ECAM. 2022; 2022: 4096005. https://doi.org/10.1155/2022/4096005.