Incidence and Risk Factors for Symptomatic Myocardial Ischemia After Posterior Decompressive Surgery for Degenerative Lumbar Disorders

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Research Article

Keywords: postoperative symptomatic myocardial ischemia, posterior decompressive surgery, degenerative lumbar disorders, insufficient daily liquid intake, cardiac surgery history

DOI: https://doi.org/10.21203/rs.3.rs-142663/v1

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Abstract

**Background:** This study aimed to determine the incidence of symptomatic myocardial ischemia (PSMI) after posterior decompressive surgery for degenerative lumbar disorders and identify its risk factors.

**Methods:** 256 patients who underwent the posterior decompressive surgery and were discharged from the hospital between January 2011 and December 2016 were enrolled in this study, according to the inclusion and exclusion criteria. Subjects were divided into two groups by the occurrence of PSMI: the PSMI group and the N-PSMI group. Three sets of factors were analyzed to investigate potential risk factors for PSMI. Patient characteristics included age, gender, body mass index, smoking, drinking, venous thrombosis of lower extremities, comorbidities, visual analog scale, hemoglobin, electrolytes. Preoperative cardiac functional variables included electrocardiogram, ventricular ejection fraction, history of ischemic attack, previous cardiac surgery. Perioperative variables included surgical strategy, surgery time, blood loss, intraoperative aortic injury, intraoperative maximum heart rate, arterial blood pressure, postoperative temperature, daily liquid intake and output volume, electrolytes glucose, drug allergy, and postoperative visual analog scale. Univariate analyses followed by the multivariate logistic regression model were employed to identify the risk factors for PSMI.

**Results:** PSMI was developed in 23 of 256 patients (8.9%) before discharge. Univariate analyses revealed that patients with onset of PSMI were older, more likely to have undergone cardiac surgery, with less daily liquid intake volume, and less intravenous infusion ($p < 0.05$). Logistic regression analysis revealed that age > 52 years, heart rate > 81 Bpm, daily liquid intake < 2140 mL, and cardiac surgery history were independently associated with PSMI after posterior decompressive surgery for degenerative lumbar disorders.

**Conclusions:** The incidence of PSMI after posterior decompressive surgery for degenerative lumbar disorders was 8.9%; senior, fast heart rate, insufficient daily liquid intake, and cardiac surgery history are potential risk factors and should be carefully evaluated before an operation.

**Background**

Degenerative lumbar disorders (DSD), including lumbar disc herniation, lumbar stenosis, lumbar spondylolisthesis, are disabling [1]. Often accompanied by symptoms such as low back pain (LBP), lower extremity pain, and weakness, DSD lead to substantial years lived with disability (YLDs) [1, 2]. According to GBD 2019 Diseases and Injuries Collaborators, LBP was the leading cause of YLDs, responsible for 63.7 million YLDs, or 7.4% of total global YLDs in 2019 [3]. During the past decade, related YLDs has increased by 13.1%, indicating an increasing healthcare burden [3]. Due to a decrease in fertility rates and an increase in life expectancy, the global population is undergoing an upward shift in its age structure [4]. The increasing aging of the population poses unique challenges for the health care system and spinal physicians. On the one hand, this is due to the more prevalent age-related degenerative lumbar diseases; on the other hand, this is because the elderly population is often comorbid with multiple chronic conditions.
Degenerative lumbar disorders have become an extensive reason to undergo lumbar spinal surgeries [1, 6]. However, the surgical treatment of DSD is not without risk of perioperative complications, particularly for those aging patients [5].

Postoperative cardiac events are frequent complications for patients undergoing various non-cardiac surgery [7], contributing to substantial morbidity and mortality and excessive hospital costs and length of stay [8–11]. Their incidence ranged from 1–16%, depending on the study population, the procedure types, and the definition of myocardial events [10, 12–14]. The clinical symptoms may vary from silent heart attacks with electrocardiogram abnormality alone to symptomatic myocardial ischemia with electrocardiogram abnormality, the elevation of isoenzyme, as well as severe clinical symptoms, such as chest pain, pressure within the anterior mid-chest, sometimes with radiation of pain to the neck, lower jaw, teeth, anns, or elbows [15]. For the patients with postoperative symptomatic myocardial ischemia (PSMI), most present no serious consequence, and the management could be not challenging. However, some cases may be life-threatening after onset, and their impact on the long-term quality of life should never be underestimated. Postoperative myocardial ischemia is associated with a 55% lower survival rate over the first five years postoperatively [16].

Multiple previous studies investigated the incidence and risk factors of myocardial ischemia after non-cardiac surgeries. In a cohort of 16,363 patients undergoing vascular surgery, the incidence of postoperative myocardial ischemia was 3%, with risk factors including procedure type and history of coronary artery disease [16]. In a prospective cohort of 2,018 patients undergoing 2,546 non-cardiac procedures, the incidence of acute myocardial infarction reached 5.8% [10]. Results from a large retrospective cohort of 30,339 patients who underwent spine surgery reported the incidence of perioperative cardiac complications (cardiac arrest or myocardial infarction) was 0.34% [11]. They found that old age, insulin-dependent diabetes, perioperative anemia, and history of cardiac diseases and treatments were risk factors for cardiac arrest or myocardial infarction [11]. To the best of our knowledge, few studies have investigated the incidence and risk factors of symptomatic myocardial ischemia (SMI) after posterior decompressive surgery for degenerative lumbar disorders. Therefore, the purpose of this study was to identify the incidence of postoperative symptomatic myocardial ischemia (PSMI) in-hospital after posterior decompressive surgery for degenerative lumbar diseases and to identify its risk factors. This study would like to provide references for spinal surgeons in decision-making and surgical planning for the most vulnerable patients.

**Methods**

**Patients**

This study is a retrospective study. The inclusion criteria included a) Degenerative lumbar disorders, including lumbar disc herniation, lumbar stenosis, lumbar spondylolisthesis; b) Posterior decompressive surgery with/without instrumented fusion; and c) Detailed and complete medical data, including history, comorbidity. The exclusion criteria included a) Patients treated for nondegenerative disorders, such as
trauma, tumor, infection, inflammation, metabolic disease, rheumatoid arthritis; b) Patients treated with anterior or lateral lumbar fusion surgery, minimally invasive lumbar fusion surgery, or c) Non-cardiac-cause death in hospital. By retrieving the medical records from January 2011 to December 2016, 256 patients (152 female and 104 male) who met both the inclusion and exclusion criteria were retrospectively reviewed. The mean age was 51.8 ± 11.3 years (range from 26 to 78 years).

**Clinical data collection and evaluation**

Postoperative symptomatic myocardial ischemia in-hospital was defined as the combination of clinical symptom, Electrocardiogram abnormality, as well as elevation of isoenzyme, including creatine kinase-MB (CK-MB) isoenzyme, myoglobin (MYO), cardiac troponin I (cTnl), brain natriuretic peptide (BNP). Patients present with a broad spectrum of symptoms, including chest pain, radiative pain of the shoulder and back. Electrocardiogram abnormality includes either new Q waves in at least two leads that were 0.04 seconds in duration and 1 mm in depth, new ST segment depression of 1 mm or more, or new T-wave inversion. According to the occurrence of PSMI in-hospital, patients were divided into two groups: the PSMI group and the N-PSMI group.

To investigate risk factors for the occurrence of postoperative symptomatic myocardial ischemia, three sets of factors were analyzed: a) Patient characteristics include age, gender, body mass index (BMI), smoking, drinking, venous thrombosis of lower extremities, comorbidities (hypertension, diabetes, chronic obstructive pulmonary disease, immunosuppressive disorder, liver disease includes patients with a documented cirrhosis or chronic hepatitis, kidney disease, bleeding disorders), preoperative visual analog scale (VAS) for pain evaluation (back and leg pain), preoperative laboratory values of hemoglobin, electrolytes (K⁺, Na⁺, Ca²⁺), and glucose. b) Preoperative cardiac functional variables include ECG, echocardiography (ventricular ejection fraction), history of ischemic attack (MI without current symptoms, stable angina, or unstable angina), previous cardiac surgery, including heart stent implantation, coronary bypass graft procedure (CABG). c) Perioperative variables include surgical strategy (decompressive surgery only or combined with instrumented fusion), surgery time, blood loss, intraoperative aortic injury, intraoperative maximum heart rate and arterial blood pressure (systolic and diastolic blood pressure), postoperative temperature, daily liquid intake (including intravenous infusion, oral intake) and output volume (including somatosensory evaporation, excreted by the kidney and intestinal discharge, wound drainage), electrolytes (K⁺, Na⁺, Ca²⁺), glucose, drug allergy, postoperative VAS for incision, back and leg pain.

**Statistical analysis**

Data analyses were conducted using Statistical Product and Service Solutions software (version 13; SPSS, Chicago, IL). Continuous variables were described as mean ± standard deviation (SD), and categorical variables were expressed as frequency and percentages. Differences in patient demographics were determined by Student's t-test for continuous variables and chi-square or Fisher's exact test for
dichotomous data as appropriate. Variables with $p$ values smaller than 0.05 in the univariate analyses and several variables selected by experts entered into a multivariate logistic regression model. We computed the odds ratio (OR) with its 95% confidence interval (CI) for each variable. $P$-value of less than 0.05 was considered as statistically significant.

**Results**

Postoperative symptomatic myocardial ischemia was developed in 23 of 256 patients (8.9%) before discharge and was enrolled as the PSMI group. The other 233 patients who presented no postoperative symptomatic myocardial ischemia were enrolled as the N-PSMI group. The mean duration from immediate postoperative to the onset of PSMI was 3.4 days.

There was no statistically significant difference between the two groups in patient characteristics of gender, BMI, smoking, drinking, lower extremity venous thrombosis, comorbidities, VAS-back, VAS-leg, hemoglobin, electrolytes, glucose. However, subjects in the PSMI group were statistically older than those in the N-PSMI group (Table 1).
| Variables                               | PSMI group | N-PSMI group | p value |
|-----------------------------------------|------------|--------------|---------|
| (n = 23)                                | (n = 233)  |              |         |
| Age, years (SD)                         | 64.9 ± 8.9 | 50.5 ± 10.7  | < 0.001 |
| Sex, n (%)                              |            |              | 0.550   |
| Female                                  | 15(65.2)   | 137(58.8)    |         |
| Male                                    | 8(34.8)    | 96(41.2)     |         |
| BMI, Kg/m² (SD)                         | 24.9 ± 1.7 | 24.5 ± 2.4   | 0.397   |
| Smoking, n (%)                          |            |              | 0.692   |
| Yes                                     | 6(26.1)    | 57(24.5)     |         |
| No                                      | 17(73.9)   | 176(75.5)    |         |
| Drinking, n (%)                         |            |              | 0.771   |
| Yes                                     | 5(21.7)    | 51(21.9)     |         |
| No                                      | 18(78.3)   | 182(78.1)    |         |
| Lower extremity venous thrombosis, n (%)|            |              | NA      |
| Yes                                     | 0(0)       | 2(0.9)       |         |
| No                                      | 23(100.0)  | 231(99.1)    |         |
| Comorbidities, n (%)                    |            |              |         |
| Hypertension                            | 16(69.6)   | 126(54.1)    | 0.154   |
| Diabetes                                | 9(39.1)    | 78(33.5)     | 0.585   |
| Chronic obstructive pulmonary disease   | 2(8.7)     | 17(7.3)      | 0.683   |
| Immunosuppressive disorder              | 1(4.3)     | 8(3.4)       | 0.577   |
| Liver disease                           | 1(4.3)     | 7(3.0)       | 0.534   |
| Kidney disease                          | 2(8.7)     | 5(2.1)       | 0.123   |
| Bleeding disorders                      | 0(0)       | 2(0.9)       | -       |
| VAS- back pain, points (SD)             | 4.9 ± 1.6  | 4.7 ± 1.6    | 0.695   |
| VAS- leg pain, points (SD)              | 4.9 ± 1.6  | 4.7 ± 1.6    | 0.601   |

PSMI symptomatic myocardial ischemia, BMI body mass index, VAS visual analog scale, mEq/L milliequivalents per liter, mmol/L millimoles per liter, SD standard deviation
| Variables | PSMI group | N-PSMI group | p value |
|-----------|------------|--------------|---------|
| Hemoglobin, g/L (SD) | 123.0 ± 11.8 | 125.2 ± 8.8 | 0.287 |
| Electrolytes | | | |
| K+, mEq/L (SD) | 4.2 ± 0.5 | 4.3 ± 0.4 | 0.108 |
| Na+, mEq/L (SD) | 142.2 ± 2.9 | 143.1 ± 2.3 | 0.061 |
| Ca+, mg/dL (SD) | 2.3 ± 0.2 | 2.3 ± 0.1 | 0.272 |
| Glucose, mmol/L (SD) | 5.7 ± 1.1 | 5.8 ± 0.9 | 0.697 |

PSMI symptomatic myocardial ischemia, BMI body mass index, VAS visual analog scale, mEq/L milliequivalents per liter, mmol/L millimoles per liter, SD standard deviation

No statistically significant difference was observed for preoperative cardiac functional variables of ECG, ventricular ejection fraction, history of ischemic attack between the two groups. However, subjects in the PSMI group were more likely to have undergone cardiac surgery than their counterparts in the N-PSMI group (Table 2).
Table 2
Preoperative cardiac function between the PSMI and N-PSMI group

| Variables                                                                 | PSMI group | N-PSMI group | p value |
|---------------------------------------------------------------------------|------------|--------------|---------|
|                                                                            | (n = 23)   | (n = 233)    |         |
| ECG                                                                       |            |              | 0.779   |
| Normal                                                                    | 18         | 190          |         |
| Myocardial ischemia                                                       | 5          | 43           |         |
| Ventricular ejection fraction, percentage (SD)                            | 66.4 ± 8.2 | 67.6 ± 9.6   | 0.577   |
| History of ischemic attack                                               |            |              | 0.086   |
| No                                                                        | 16         | 196          |         |
| MI without current symptoms                                              | 3          | 17           |         |
| Stable angina                                                             | 2          | 12           |         |
| Unstable angina                                                           | 2          | 8            |         |
| Previous cardiac surgery                                                 |            |              | < 0.001 |
| No                                                                        | 11         | 217          |         |
| Heart stent implantation                                                 | 5          | 12           |         |
| CABG                                                                      | 7          | 4            |         |

PSMI symptomatic myocardial ischemia, ECG electrocardiogram, MI myocardial infarction, CABG coronary bypass graft procedure

There was no statistically significant difference between the two groups in perioperative variables of surgical strategy, surgery time, blood loss, intraoperative aortic injury, intraoperative maximum heart rate, and arterial blood pressure, postoperative temperature, electrolytes, Glucose, drug allergy, postoperative VAS for incision, back and leg pain, daily liquid oral intake, the liquid output volume of excreted by the kidney and wound drainage. However, the overall daily liquid intake and intravenous infusion were statistically smaller in the PSMI group than in the N-PSMI group (Table 3).
| Variables                                      | PSMI group | N-PSMI group | p value |
|------------------------------------------------|------------|--------------|---------|
| (n = 23)                                       | (n = 233)  |              |         |
| Surgical strategy, n (%)                       |            |              | 0.877   |
| Decompressive surgery only                     | 7(30.4)    | 53(22.7)     |         |
| TLIF                                           | 11(47.8)   | 85(36.5)     |         |
| PLIF                                           | 15(62.5)   | 95(40.8)     |         |
| Surgery time, minutes (SD)                     | 152.6 ± 13.6| 156.6 ± 18.4 | 0.310   |
| Blood loss, mL (SD)                            | 524.8 ± 71.4| 546.1 ± 71.7 | 0.176   |
| Intraoperative aortic injury, n (%)            |            |              | NA      |
| Yes                                            | 0(0)       | 0(0)         |         |
| No                                             | 23(100.0)  | 233(100)     |         |
| Intraoperative maximum heart rate, bpm (SD)    | 84.0 ± 9.7 | 80.6 ± 10.2  | 0.117   |
| Systolic blood pressure, mmHg (SD)             | 130.0 ± 7.3| 132.8 ± 8.7  | 0.141   |
| Diastolic blood pressure, mmHg (SD)            | 81.0 ± 10.2| 83.7 ± 10.9  | 0.256   |
| Postoperative temperature, °C (SD)             | 37.6 ± 3.8 | 38.9 ± 2.0   | 0.745   |
| Electrolytes                                   |            |              |         |
| K+, mEq/L (SD)                                 | 4.2 ± 0.4  | 4.1 ± 0.5    | 0.284   |
| Na+, mEq/L (SD)                                | 142.1 ± 2.7| 141.7 ± 3.1  | 0.574   |
| Ca+, mg/dL (SD)                                | 2.3 ± 0.1  | 2.3 ± 0.2    | 0.245   |
| Glucose                                        | 5.8 ± 1.1  | 5.8 ± 1.1    | 0.813   |
| Drug allergy, n (%)                            |            |              | 0.315   |
| Yes                                            | 1(4.3)     | 3(1.3)       |         |
| No                                             | 22(95.7)   | 230(98.7)    |         |
| VAS-incision pain, points (SD)                 | 4.9 ± 1.8  | 4.6 ± 1.5    | 0.339   |
| VAS-back pain, points (SD)                     | 4.5 ± 1.4  | 4.7 ± 1.3    | 0.532   |
| VAS-leg pain, points (SD)                      | 4.4 ± 1.4  | 4.6 ± 1.5    | 0.556   |

PSMI symptomatic myocardial ischemia, TLIF transforaminal lumbar interbody fusion, PLIF posterior lumbar interbody fusion, bpm beats per minute, VAS visual analog scale
The following variables entered into the multivariate model: age, gender, BMI, smoking, drinking, venous thrombosis of lower extremities, comorbidities, preoperative VAS-back, VAS-leg, K⁺, Na⁺, Ca²⁺, Glucose, ECG, ventricular ejection fraction, history of ischemic attack, previous cardiac surgery, surgical strategy, postoperative temperature, daily liquid intake, output volume, postoperative K⁺, Na⁺, Ca²⁺, Glucose, drug allergy, postoperative VAS for incision, back and leg pain. When included in a binary logistic regression model, age > 52 years, heart rate > 81 Bpm, daily liquid intake < 2140 mL and cardiac surgery history were independently associated with the onset of postoperative symptomatic myocardial ischemia after posterior decompressive surgery for degenerative lumbar disorders (Table 4).

### Table 4
Factors associated with PSMI after posterior decompressive surgery for degenerative lumbar disorders

| Variable                      | Odds ratio [95% CI] | p value |
|-------------------------------|--------------------|---------|
| Age                           | 0.04 [0.006–0.253] | 0.001   |
| Heart rate                    | 0.09 [0.019–0.443] | 0.003   |
| Daily liquid intake           | 4.88 [1.179–20.236]| 0.029   |
| Cardiac surgery history       | 44.09 [7.232–268.870]| < 0.001|

PSMI: symptomatic myocardial ischemia

### Discussion

In the current study, most patients who underwent posterior decompressive surgery for degenerative lumbar disorders achieved satisfactory clinical outcomes. However, 8.9% of the patients experienced postoperative symptomatic myocardial ischemia, resulting in the decreased overall surgical outcome and
patient satisfaction. Most of these events occurred within the first four days after surgery, with the risk declining sharply after the third postoperative day. Age > 52 years, heart rate > 81 Bpm, daily liquid intake < 2140 mL, and cardiac surgery history were independently associated with postoperative symptomatic myocardial ischemia after posterior decompressive surgery for degenerative lumbar disorders. These results were not confounded by other variables potentially associated with PSMI.

Due to the frequently degenerative nature of the lumbar spine, the afflicted population tends to be older, often with multiple medical comorbidities, such as hypertension, diabetes, cardio-cerebrovascular disease, pulmonary disease, etc. Even in the absence of comorbid conditions, older patients demonstrate diminished physiologic reservation compared to the younger counterparts, including cardiac, renal, pulmonary, and immunologic functions contributing to an increased vulnerability to external insults. General anesthesia is a routine method in posterior decompressive surgery for degenerative lumbar disorders. Intraoperative decreases in pressure occur almost universally during inhalation anesthesia because halothane, isoflurane, and enflurane all produce a dose-related depression of myocardial contractility. The compensatory ability for hemodynamic changes (hypotension, bradycardia, and decreased pulmonary capillary wedge pressure) is diminished in elderly patients. The hemodynamic changes induced by anesthesia induction and revival procedure, intraoperative mass blood loss, may cause myocardial infarction. In the current study, age older than 52 years is found to be a potential risk factor for myocardial infarction, partly consistent with Goldman's findings, in which age over 70 years was identified as a risk factor for postoperative myocardial infarction [17]. The ten-year difference in age between our study and Goldman may be due to the racial disparity and the difference in diagnosis included in the two studies. Nitroglycerin was proved to prevent intraoperative myocardial infarction by improving coronary arterial blood flow in 1980 [18]. However, intraoperative prophylactic use of nitroglycerin in high-risk patients may have negligible benefits or may even be harmful, leading to cardiovascular decompensation through decreased preload [19]. Several studies demonstrate that nitroglycerin administered as a prophylactic against myocardial infarction caused hemodynamic changes that may have led to an increased incidence of intraoperative myocardial infarction due to the altered hemodynamic responses [20, 21]. However, older patients should not be excluded from the benefit of surgery, given that their overall improvements of Oswestry Disability Index (ODI) and pain relief were equivalent to those of patients without postoperative myocardial infarction. Given the correlation of age and the risk of postoperative myocardial infarction, a thorough understanding of the interplay between postoperative myocardial infarction and surgical outcomes will be vital to optimizing clinical decision-making and appropriate patient counseling before surgery. For spinal surgeons and anesthesiologists, avoidance of significant hemodynamic changes during the perioperative period should be followed.

Previous studies have demonstrated that patients with prior myocardial infarction, particularly those who had an infarction within six months before surgery, are at increased risk for postoperative infarction. Those with angina alone were not [22–25]. For patients with pre-existing coronary artery disease undergoing non-cardiac surgery, the risk of cardiac complications is known to be higher [16, 26]. Most of the degenerative lumbar disorders do not need an emergency operation; comprehensive preoperative assessment of surgical and anesthesia risks, especially the cardiovascular and respiratory function, is
necessary as time permits. Based on the understanding of the above point, patients with myocardial infarction or angina within six months before are not recommended to receive surgery unless in particular circumstances in our medical center. However, we did find that patients who received cardiac surgical intervention six months ago, including coronary artery bypass grafting (CABG) and percutaneous coronary intervention (PCI), assume a greater risk of postoperative myocardial infarction. There are two possible explanations for it. First, while at rest, the heart receives 4% of the cardiac output, although 10% of the systemic oxygen consumption is cardiac [27]. It results in a high degree of oxygen extraction across the coronary vascular bed. The heart increases its myocardial oxygen supply by increasing its oxygen extraction and increasing the total coronary blood flow. Under normal conditions, this increase can be up to five times the resting flow. Both the CABG and PCI are the recommended treatment methods for severe coronary artery disease involving multiple vessels or the left main stem; the patients always present poor cardiac function and lower compensatory capacity [28]. Second, revascularization with CABG and PCI are options for patients presenting with angina pectoris on optimal medical therapy. However, the repeat revascularization rate is 25.9% after PCI and 13.7% after CABG, both of which are not much higher. Delay of revascularization could result in irreversible loss of cardiac function. The surgical intervention could mechanically expand the narrowed coronary vessels but not improve vascular biological performance. Kappetein et al. [29] revealed that major adverse cardiac and cerebrovascular events (MACCE) were 26.9% in the CABG group and 37.3% in the PCI group after five years of follow-up. In other words, surgical intervention may temporarily relieve myocardial ischemia symptoms but not prevent the recurrence of myocardial infarction permanently.

The intraoperative blood loss varied from 300 mL to 1000 mL in the surgical treatment for degenerative lumbar disorders, depending on the surgery time, surgeon's experience, blood coagulation status, etc. Humans have a multitude of survival compensatory neuroendocrine mechanisms, which allow them to tolerate up to 30% of circulating blood volume loss before changes in traditional vital signs are evident, such as heart rate, blood pressure, respiratory rate, and oxygen saturation [30, 31]. Postoperatively, fluid resuscitation or blood transfusion should be implemented to maintain hemodynamic stability. The liquid intake and output volume need to be balanced. Gold JP et al. demonstrated that patients with larger hourly urine output did have a higher rate of ischemic complications, although this did not reach significance [32]. In the current study, the overall liquid output-intake difference of more than 800 mL was a potential risk factor for postoperative symptomatic myocardial ischemia.

In contrast, the amount of intraoperative blood loss is not. Postoperatively, if the liquid intake was not enough or the fluid output was excessive (use of mannitol or diuretic, somatosensory evaporation), the insufficient blood volume may induce a series of compensatory adaptations in the body, especially the increase of venous return and rapid heartbeat. Heart rate is an essential determinant of myocardial oxygen consumption: the faster the heart rate, the greater the amount of oxygen consumed per given time period. It is because the number of contractions per minute increased. Slogoff and Keats’ showed a twofold increase in the frequency of ischemia associated with a heart rate above 100 bpm. By analyzing the ST segment trends, it appears that heart rate increase precedes ST depression, which suggests a cause-and-effect relationship [30]. Moreover, the autonomic nervous system plays a significant role in the
pathophysiology of perioperative ischemia. There is evidence that sympathetic activation has an essential role in the onset of adverse cardiac events [30]. Adrenergic activity and plasma catecholamine levels change considerably in the postoperative period, which may predispose myocardial ischemia by altering the relationship between myocardial oxygen demand and supply [33].

There were several potential limitations in this study. First, this is a single-center study with a limited sample size. Only 256 patients were enrolled. Therefore, the study may be prone to type two error and underpowered to detect the significance of some potential risk factors. Thus, a multi-center large sample study is required. Second, only Chinese Han individuals were included in this study, and ethnic variation was not covered.

Conclusions

Our study revealed that older age (more than 52 years), fast heart rate (more than 81 Bpm), insufficient daily liquid intake (less than 2140 mL), and cardiac surgery history were potential risk factors for postoperative symptomatic myocardial ischemia after posterior decompressive surgery for degenerative lumbar disorders. Based on the above findings, patients of older age or with cardiac surgery history should be fully informed of the risk of postoperative symptomatic myocardial ischemia. It is essential for surgeons to control the heart rate and prevent insufficient daily liquid intake in postoperative patient management.

List Of Abbreviations

PSMI: symptomatic myocardial ischemia; Bpm:beats per minute; DSD:degenerative lumbar disorders; YLDs:years lived with disability; GBD:Global Burden of Diseases, Injuries, and Risk Factors Study; SMI:symptomatic myocardial ischemia; CK-MB:creatine kinase-MB; MYO:myoglobin; cTnl:cardiac troponin I, BNP:brain natriuretic peptide; BMI:body mass index; VAS:visual analog scale; CABG:coronary bypass graft procedure; SD:standard deviation; OR:odds ratio; CI:confidence interval; ODI:Oswestry Disability Index; PCI:percutaneous coronary intervention; MACCE:major adverse cardiac and cerebrovascular events; MI:myocardial infarction; TLIF:transforaminal lumbar interbody fusion; PLIF:posterior lumbar interbody fusion; ECG:electrocardiogram

Declarations

Acknowledgements

Not applicable.

Authors’ contribution
All authors contributed to drafting, revising the manuscript, and gave final approval of the version to be published. WJL designed the study, collected and analyzed the data, and drafted the initial manuscript. SSZ and YL took part in the interpretation of the results. HYH critically reviewed the manuscript for important intellectual content.

**Funding**

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

**Availability of data and materials**

All data generated or analyzed during this study are included in this published article.

**Ethics approval and consent to participate**

The data did not contain any information that may disclose the privacy of patients. Analysis of data did not do any harm to the patients involved. The study did not have a commercial purpose. The study protocol was approved by the ethics committee of the First College of Clinical Medical Science, China Three Gorges University and Yichang Central People's Hospital. The informed consent from the participants was waived by the Institutional Review Board (IRB) of the First College of Clinical Medical Science, China Three Gorges University and Yichang Central People's Hospital.

**Consent for publication**

Not applicable.

**Competing interests**

The authors declare that they have no competing interests.

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