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Original Article

Perioperative antiplatelet management in CAD patients undergoing spinal fusion: balancing cardiovascular safety and bleeding risk

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Abstract: Background: For patients with coronary artery disease (CAD) who require long-term antiplatelet therapy, controversy remains regarding perioperative drug management strategies during spinal fusion surgery, with balancing thrombotic and bleeding risks being key to clinical decision-making. Objective: This study aims to retrospectively compare the impact of four perioperative antiplatelet drug management strategies (continuing medication, discontinuing medication 5 days before surgery, discontinuing medication 7 days before surgery, and bridging therapy) on cardiovascular safety and bleeding risk in CAD patients undergoing spinal fusion surgery. Methods: This is a single-center retrospective cohort study. It includes 325 patients with CAD who underwent elective spinal fusion surgery between January 2018 and December 2023. Patients were divided into four groups based on their perioperative antiplatelet management strategy. The primary outcome was major adverse cardiovascular events (MACE) within 30 days post-surgery, while secondary outcomes included bleeding events, intraoperative blood loss, postoperative drainage volume, and transfusion requirements. Results: Baseline characteristics were generally balanced across the four groups. The group continuing medication had the highest incidence of bleeding events (31.9%), whereas the group discontinuing medication 7 days preoperatively had the lowest (6.7%), with significant differences observed (P<0.001). Regarding cardiovascular events, the incidence was relatively lower in the group continuing medication, with higher risk in the discontinuation groups (especially the 5-day discontinuation group); multivariate regression showed that discontinuing medication for 5 days was an independent risk factor for MACE (OR=3.87, P=0.038). The bridging therapy group exhibited intermediate levels of both bleeding and cardiovascular risk. Intraoperative blood loss and postoperative transfusion rates were also significantly higher in the continuing medication group. Conclusions: In spinal fusion surgeries among CAD patients, continuing antiplatelet medication provides better cardiovascular protection but significantly increases bleeding risk; discontinuing medication preoperatively can effectively reduce bleeding complications but may increase the risk of cardiovascular events; while bridging therapy achieves a relative balance between the two. Clinical decisions should be individualized, comprehensively assessing the patient's thrombotic and bleeding risks.

Keywords: Antiplatelet therapy, perioperative management, spinal fusion surgery, coronary artery disease, cardiovascular safety, bleeding risk

Introduction

With the acceleration of population aging in society, the co-morbidity of coronary atherosclerotic heart disease (CAD) and degenerative spinal diseases is becoming increasingly common [1-3]. As an important surgical treatment for severe spinal degeneration, instability, or deformity, the demand for spinal fusion surgery has been growing annually [4, 5]. For patients with CAD, antiplatelet drugs (such as aspirin, clopidogrel, etc.) are the cornerstone of secondary prevention, effectively reducing the risk of ischemic cardiovascular events like stent thrombosis and myocardial infarction [6]. However, when these patients need to undergo elective spinal fusion surgery due to spinal lesions, whether and how to manage antiplate-

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let therapy during the perioperative period becomes a highly challenging clinical decision [7, 8].

The core of perioperative management strategies lies in balancing two major risks: on one hand, continuing antiplatelet drugs may significantly increase intraoperative and postoperative bleeding risks, including increased bleeding at the surgical site, hematoma formation, wound complications, higher transfusion requirements, and even nerve compression or surgical failure due to bleeding; on the other hand, discontinuing medication preoperatively can reduce bleeding-related complications but may lead to "rebound" platelet reactivity due to interruption of antiplatelet effects, significantly increasing the risk of major adverse cardiovascular events (MACE) such as perioperative acute coronary syndrome, stent thrombosis, myocardial infarction, and even sudden cardiac death [9]. This risk is particularly pronounced in patients who have had recently implanted drug-eluting stents or those who belong to high thrombotic risk groups [10].

Currently, relevant clinical guidelines at home and abroad provide certain recommendations for perioperative antiplatelet drug management in non-cardiac surgeries, but most are based on expert consensus and research evidence from cardiovascular or low-bleeding-risk surgeries, leading to sometimes inconsistent recommendations [11-13]. For spinal surgeries, which have moderate to high bleeding risks, specialized and high-quality research evidence remains limited. Existing literature mostly focuses on descriptions of single strategies or small-sample observations, lacking systematic head-to-head comparisons of different management strategies (especially "continuing medication", "discontinuing medication for varying durations preoperatively", and "bridging anticoagulation therapy") in patients undergoing spinal fusion. This gap in evidence leads to significant variations in strategy choices in clinical practice, decisions often relying on physician experience and local habits rather than strong evidence-based support [14-16].

Therefore, to fill this knowledge gap and provide more operational decision-making references for clinical use, this study aims to systematically evaluate and compare four common perioperative antiplatelet drug management strategies - namely, continuing medication perioperatively, discontinuing medication 5 days preoperatively, discontinuing medication 7 days preoperatively, and using low molecular weight heparin/unfractionated heparin for bridging therapy - on cardiovascular safety (with MACE as the primary endpoint) and bleeding risk within 30 days post-surgery in CAD patients undergoing elective spinal fusion surgery. The findings of this study are expected to provide important real-world evidence for optimizing perioperative management of such complex comorbid patients, promoting patient-centered individualized, multidisciplinary collaborative decision-making models.

Materials and methods

General information

This study is a retrospective observational cohort study, approved by the Ethics Review Committee of Jingmen Hospital of Traditional Chinese Medicine, with a waiver of informed consent. Due to the retrospective, observational nature of the study, which involved analyzing data already collected as part of routine clinical care, the requirement for informed consent was formally waived by the committee. All procedures performed in this study involving human participants were in accordance with the Declaration of Helsinki (as revised in 2013).

Study population and grouping

The study consecutively enrolled coronary artery disease (CAD) patients who underwent elective spinal fusion surgery at Department of Cardiovascular Disease, Jingmen Traditional Chinese Medicine Hospital between January 1, 2018, and December 31, 2023. Patients were divided into four groups based on the actual perioperative antiplatelet drug management strategy:

Continuation group: Antiplatelet drugs were continued uninterrupted throughout the perioperative period.

5-day discontinuation group: Antiplatelet drugs were discontinued 5 days before surgery, meaning that the last dose was administered 5 days prior to the day of surgery (e.g., for surgery scheduled on Monday, the last dose was taken on the previous Wednesday).

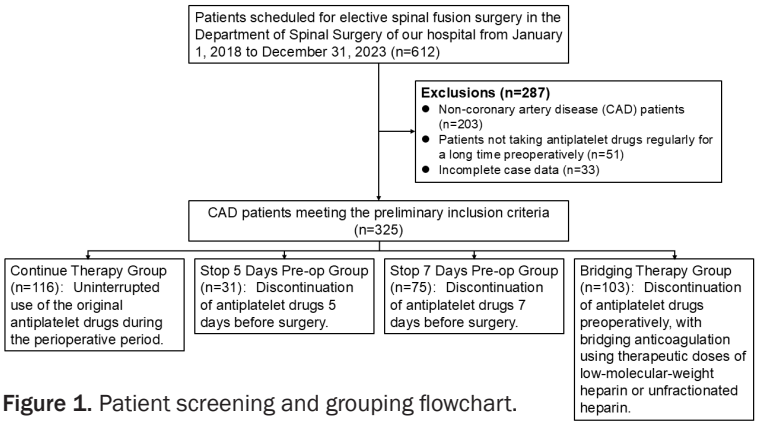

Figure 1. Patient screening and grouping flowchart.

7-day discontinuation group: Antiplatelet drugs were discontinued 7 days before surgery, with the last dose given 7 days prior to the procedure.

Bridging therapy group: Oral antiplatelet agents were discontinued prior to surgery. Bridging therapy was initiated 3-5 days before the procedure, once the antiplatelet effect had sufficiently waned - typically 48-72 hours after the last dose of clopidogrel or ticagrelor. The bridging regimen consisted of therapeutic doses of subcutaneous low molecular weight heparin (LMWH; e.g., enoxaparin 1 mg/kg twice daily) or intravenous unfractionated heparin (UFH) titrated to an activated partial thromboplastin time (aPTT) of 1.5-2.5 times the control value. The last dose of LMWH was administered at least 12-24 hours before surgery, while UFH was discontinued 4-6 hours prior to incision. Postoperatively, oral antiplatelet therapy was resumed as soon as hemostasis was confirmed and the risk of surgical-site bleeding was deemed acceptably low, typically within 24-72 hours, often with a loading dose when clinically indicated (**Figure 1**).

Inclusion and exclusion criteria

Patients were eligible for inclusion if they were aged 18 years or older, had a confirmed diagnosis of coronary artery disease (CAD) - including stable or unstable angina, history of myocardial infarction, or prior coronary revascularization with percutaneous coronary intervention (PCI) or coronary artery bypass grafting (CABG) - and had been on long-term (≥3 months) single or dual antiplatelet therapy (aspirin, clopidogrel, or ticagrelor). All patients underwent elective spinal fusion surgery (cervical, thoracic, or lumbar) involving instrumentation, and had complete medical records available, including details of antiplatelet management, surgical notes, and 30-day follow-up data.

Exclusion criteria were: emergency or urgent spine surgery; concomitant use of anticoagulants (e.g., warfarin, direct oral anticoagulants) or other antithrombotic agents; pre-existing bleeding disorders or coagulopathy; active bleeding at the time of surgery; severe hepatic impairment (Child-Pugh class C) or severe renal insufficiency (eGFR <30 mL/min/1.73 m^2); pregnancy or lactation; and incomplete 30-day postoperative follow-up data.

Data collection and outcome definitions

Data were collected through the electronic medical record system, including:

Baseline characteristics: demographic information, type and duration of CAD, comorbidities, preoperative laboratory tests.

Surgical details: surgical segments, types, duration, anesthesia methods.

Management strategy specifics: drug types, timing of discontinuation and resumption, bridging protocols.

Outcome measures: Major adverse cardiovascular events (MACE): Composite endpoint occurring within 30 days post-surgery, including cardiac death, non-fatal myocardial infarction, unstable angina requiring urgent revascularization, new or worsening heart failure, ischemic stroke, or transient ischemic attack.

Bleeding events: Defined and graded according to the BARC (Bleeding Academic Research Consortium) criteria. Types of bleeding (intraoperative, wound hematoma, gastrointestinal, intracranial, etc.), severity (minor, moderate, severe), and whether blood transfusion was required were recorded.

Other indicators: Intraoperative blood loss, postoperative drainage volume, length of hospital stay, 30-day readmission rate.

Table 1. Comparison of baseline characteristics among the four groups

Variable	Continue Therapy (n=116)	Stop 5 Days Pre-op (n=31)	Stop 7 Days Pre-op (n=75)	Bridging Therapy (n=103)	H/F/χ^2	*P*-value
Age (years)	65.74 ± 11.67	65.87 ± 11.00	66.84 ± 12.04	65.51 ± 11.36	0.734	0.865
Body Mass Index	24.70 ± 3.04	24.74 ± 2.95	24.47 ± 3.55	24.71 ± 3.25	0.111	0.954
CAD Duration (years)	9.77 ± 5.71	9.32 ± 6.02	10.17 ± 6.42	10.39 ± 5.52	1.230	0.746
Hemoglobin (g/L)	133.42 ± 14.51	138.93 ± 13.24	134.81 ± 15.17	136.58 ± 17.36	1.393	0.245
Platelet Count (×10^9/L)	290.11 ± 73.19	268.97 ± 73.19	278.77 ± 73.36	271.50 ± 72.94	4.326	0.228
Creatinine (μmol/L)	81.30 ± 22.68	86.81 ± 23.24	84.01 ± 23.43	78.22 ± 26.40	1.400	0.243
LDL-C (mmol/L)	2.81 ± 0.86	2.88 ± 0.87	2.74 ± 0.73	2.96 ± 0.74	1.177	0.318
Male Gender (%)	54.31%	58.06%	58.67%	55.34%	0.423	0.936
Previous MI (%)	56.03%	38.71%	54.67%	48.54%	3.643	0.303
Previous PCI (%)	54.31%	41.94%	46.67%	50.49%	2.009	0.571
Previous CABG (%)	43.10%	48.39%	50.67%	55.34%	3.351	0.341
Hypertension (%)	56.90%	77.42%	50.67%	48.54%	8.753	0.033
Diabetes (%)	55.17%	45.16%	53.33%	43.69%	3.503	0.320
Dyslipidemia (%)	49.14%	41.94%	61.33%	44.66%	5.866	0.118
Chronic Kidney Disease (%)	51.72%	48.39%	54.67%	50.49%	0.461	0.927
Smoking (%)	43.97%	48.39%	72.00%	44.66%	17.274	<0.001
Antiplatelet regimen					18.351	<0.001
Single antiplatelet therapy	47 (40.5%)	11 (35.5%)	34 (45.3%)	66 (64.1%)		
Dual antiplatelet therapy	69 (59.5%)	20 (64.5%)	41 (54.7%)	37 (35.9%)		
Specific antiplatelet agents					33.627	<0.001
Aspirin alone	18 (15.5%)	6 (19.4%)	16 (21.3%)	31 (30.1%)		
Clopidogrel alone	16 (13.8%)	3 (9.7%)	12 (16.0%)	20 (19.4%)		
Ticagrelor alone	13 (11.2%)	2 (6.5%)	6 (8.0%)	15 (14.6%)		
Aspirin + clopidogrel	39 (33.6%)	12 (38.7%)	24 (32.0%)	22 (21.4%)		
Aspirin + ticagrelor	30 (25.9%)	8 (25.8%)	17 (22.7%)	15 (14.6%)		

Abbreviations: BMI, Body Mass Index; CAD, Coronary Artery Disease; LDL-C, Low-Density Lipoprotein Cholesterol; MI, Myocardial Infarction; PCI, Percutaneous Coronary Intervention; CABG, Coronary Artery Bypass Grafting.

Statistical analysis

Statistical analysis was performed using SPSS 20.0 software. Normally distributed continuous variables were expressed as mean ± standard deviation, and intergroup comparisons were made using one-way ANOVA. Non-normally distributed data were presented as median (interquartile range) and compared using the Kruskal-Wallis H test. Categorical variables were expressed as frequencies (percentages), and intergroup comparisons were made using chi-square tests or Fisher's exact probability method. Multivariate logistic regression analysis was used to adjust for confounding factors and assess the independent associations between different management strategies and MACE and bleeding events, calculating odds ratios (ORs) and their 95% confidence intervals (CIs). All tests were two-sided, with a *P* value <0.05 considered statistically significant.

Results

Patient selection and baseline characteristics

A total of 325 patients were included in the final analysis, comprising 116 in the continuation group, 31 in the 5-day discontinuation group, 75 in the 7-day discontinuation group, and 103 in the bridging therapy group. Baseline characteristics were generally balanced across groups, except for a higher prevalence of hypertension (P=0.033) and smoking (P<0.001) in the 5-day discontinuation group (**Table 1**).

Analysis of bleeding outcomes

Perioperative outcomes are summarized in **Table 2**. The continuation group had the highest bleeding event rate (31.9%, 37/116), followed by bridging therapy (29.1%, 30/103), 5-day discontinuation (16.1%, 5/31), and 7-day

Table 2. Comparison of intraoperative blood loss, drainage, and transfusion requirements by management strategy

Outcomes	Continue Therapy (n=116)	Stop 5 Days Pre-op (n=31)	Stop 7 Days Pre-op (n=75)	Bridging Therapy (n=103)	*P*-value
Intraoperative Blood Loss [ml, M (IQR)]	1220 (761)	712 (431)	780 (479)	889 (545)	<0.001
Postop Drainage [ml, M (IQR)]	444 (264)	563 (256)	491 (373)	448 (284)	0.150
Transfusion Requirement [n (%)]	10 (8.6)	1 (2.3)	0 (0.0)	10 (6.8)	0.012

Statistical Test H=80.190, P<0.001. Abbreviations: IQR, Interquartile Range; M (IQR), Median (Interquartile Range).

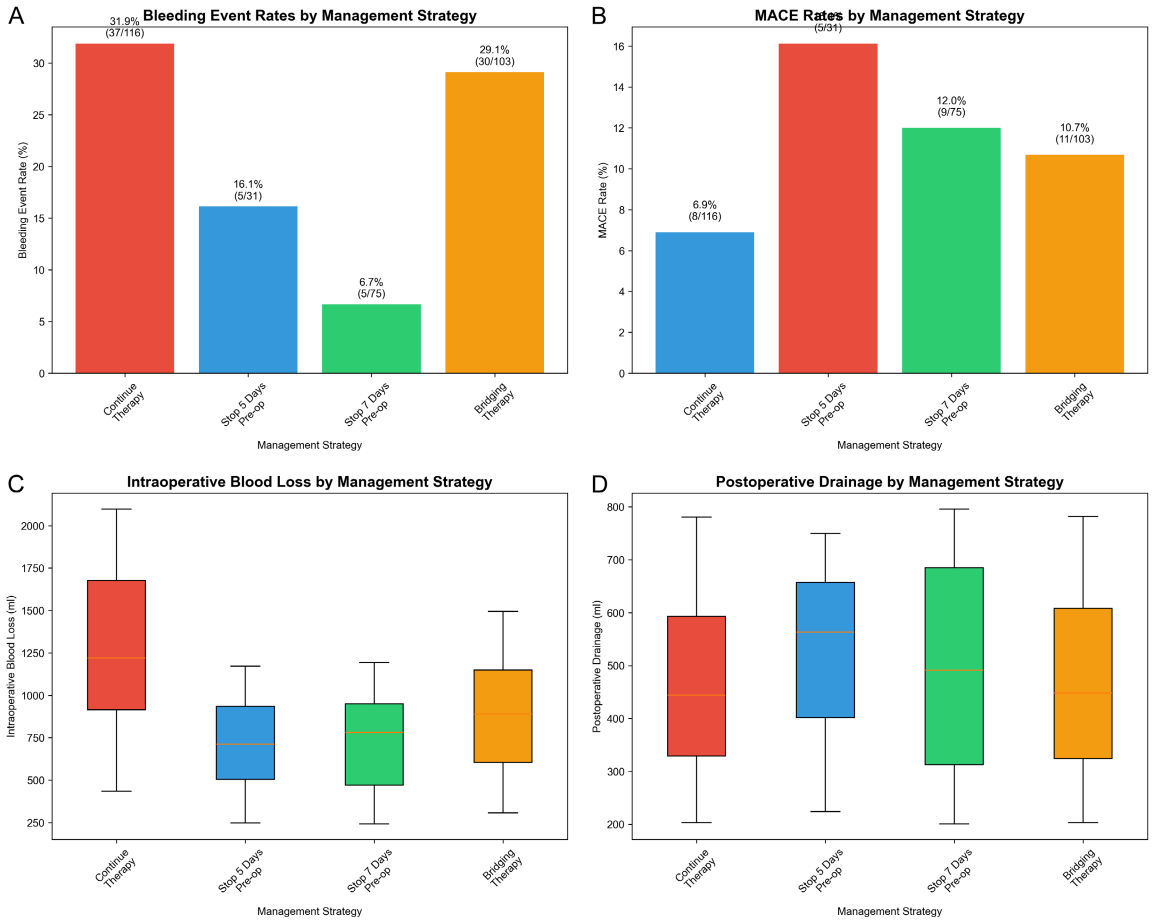

Figure 2. Perioperative outcomes by antiplatelet management strategy. A: Bleeding event rates: highest in Continue Therapy (31.9%, 37/116) and lowest in Stop 7 Days Pre-op (6.7%, 5/75) (χ^2=19.007, P<0.001). B: MACE rates: highest in Stop 5 Days Pre-op (16.1%, 5/31) and lowest in Continue Therapy (6.9%, 8/116) (χ^2=2.874, P=0.412). C: Intraoperative blood loss (median, IQR): Continue Therapy 1220 (761) mL, Stop 5 Days Pre-op 712 (431) mL, Stop 7 Days Pre-op 780 (479) mL, Bridging Therapy 889 (545) mL (H=80.190, P<0.001). D: Postoperative drainage (median, IQR): Continue Therapy 444 (264) mL, Stop 5 Days Pre-op 563 (256) mL, Stop 7 Days Pre-op 491 (373) mL, Bridging Therapy 448 (284) mL (H=5.316, P=0.150). Abbreviations: MACE: Major Adverse Cardiovascular Events; IQR: Interquartile Range.

discontinuation (6.7%, 5/75) (**Figure 2A**; χ^2=19.007, P<0.001). MACE occurred in 33 patients (10.2%). The incidence was highest in the 5-day discontinuation group (16.1%, 5/31) and lowest in the continuation group (6.9%, 8/116) (**Figure 2B**; χ^2=2.874, P=0.412). In-

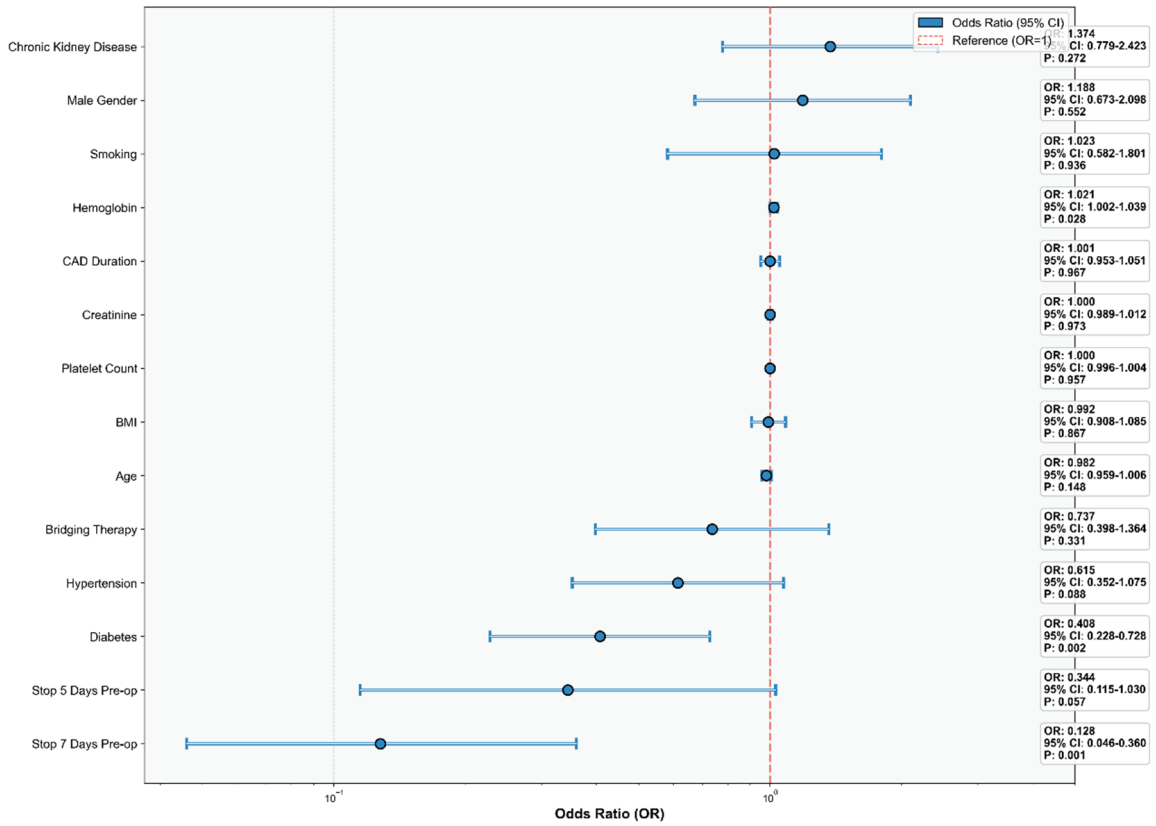

Figure 3. Multivariable logistic regression for bleeding risk. Abbreviations: BMI, Body Mass Index; CAD, Coronary Artery Disease; OR, Odds Ratio; CI, Confidence Interval.

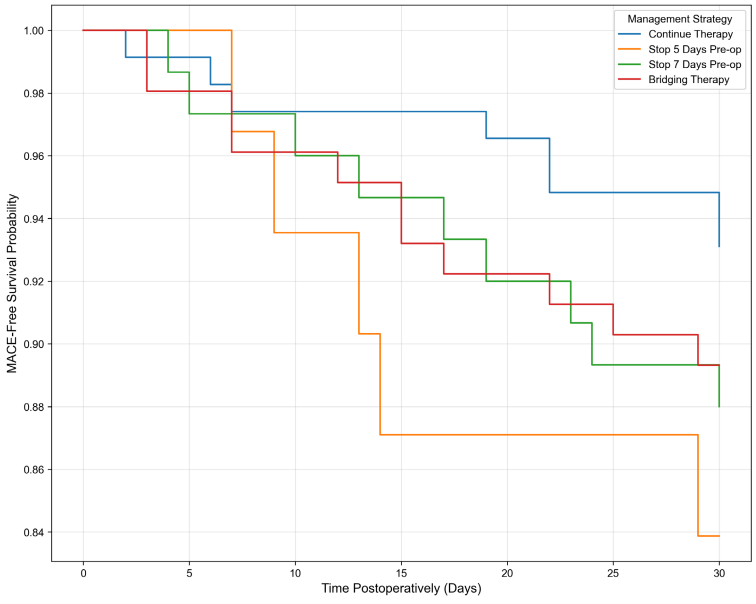

Figure 4. Kaplan-Meier curve for MACE-free survival. Abbreviations: MACE, Major Adverse Cardiovascular Events.

traoperative blood loss varied significantly (**Figure 2C**; H=80.190, P<0.001), with the continuation group showing the highest median loss [1220 (IQR 761) mL] and the 5-day discontinuation group the lowest [712 (IQR 431) mL]. Postoperative drainage did not differ significantly (**Figure 2D**; H=5.316, P=0.150). Transfusion requirements were highest in the continuation group (10 patients, 8.6%) and absent in the 7-day discontinuation group (P=0.012).

Multivariable logistic regression for bleeding risk (**Figure 3**) identified hemoglobin as a significant but clinically modest risk factor (OR=1.021, 95%CI 1.002-1.039, P=0.028), while diabetes (OR=0.408, 95%CI 0.228-0.728, P=0.002) and 7-day discontinuation (OR=0.128, 95%CI 0.046-0.360, P=0.001) were protective. Other variables showed no significant association.

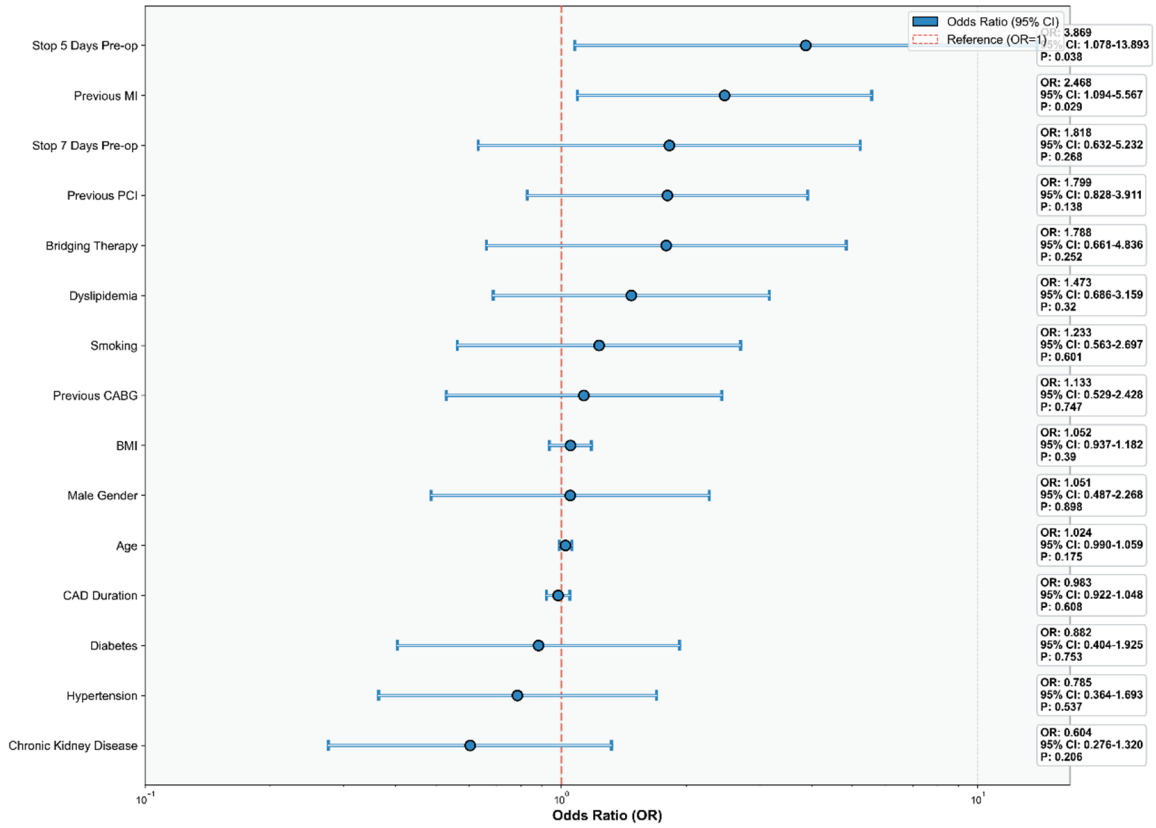

Figure 5. Multivariable logistic regression for MACE risk. Abbreviations: MI, Myocardial Infarction; PCI, Percutaneous Coronary Intervention; CABG, Coronary Artery Bypass Grafting; OR, Odds Ratio; CI, Confidence Interval.

Analysis of cardiovascular outcomes

The Kaplan-Meier curves (**Figure 4**) demonstrated that 30-day MACE-free survival was lowest in the 5-day discontinuation group (83.9%) and highest in the continuation group (93.1%). Multivariable logistic regression for MACE risk (**Figure 5**) confirmed that 5-day discontinuation (OR=3.869, 95%CI 1.078-13.893, P=0.038) and previous MI (OR=2.468, 95%CI 1.094-5.567, P=0.029) were independent risk factors. Other variables, including 7-day discontinuation and bridging therapy, were not significantly associated with MACE.

Subgroup analysis

Subgroup analysis by CAD type (**Figure 6**) revealed marked heterogeneity. In unstable angina (**Figure 6A**, n=53), bleeding was highest with continuation (55.6%), while MACE peaked with bridging therapy (25.0%). In post-PCI patients (**Figure 6B**, n=76), bleeding rates were highest with continuation (29.4%) and bridging (33.3%), but MACE remained low (≤4.8%) across all strategies. With stable angina (**Figure 6C**, n=66), bleeding was highest with bridging (40.0%) and MACE with 7-day discontinuation (18.8%). In patients with prior MI (**Figure 6D**, n=61), MACE was highest with 5-day discontinuation (37.5%) and bleeding with continuation (25.0%).

Stratification by antiplatelet therapy type (**Figure 7**) showed that in the dual-therapy subgroup (**Figure 7A**, n=167), continuation was associated with the highest bleeding (44.1%) and the lowest MACE (1.7%); bridging therapy yielded intermediate rates (bleeding 37.3%, MACE 9.3%). In the single-therapy subgroup (**Figure 7B**, n=158), continuation had 19.3% bleeding and 12.3% MACE; 5-day discontinuation showed equal rates (16.1% each); bridging therapy had the lowest bleeding (7.1%) with 14.3% MACE.

Clinical decision pathway

Based on these findings, a clinical decision pathway was constructed (**Figure 8**) that inte-

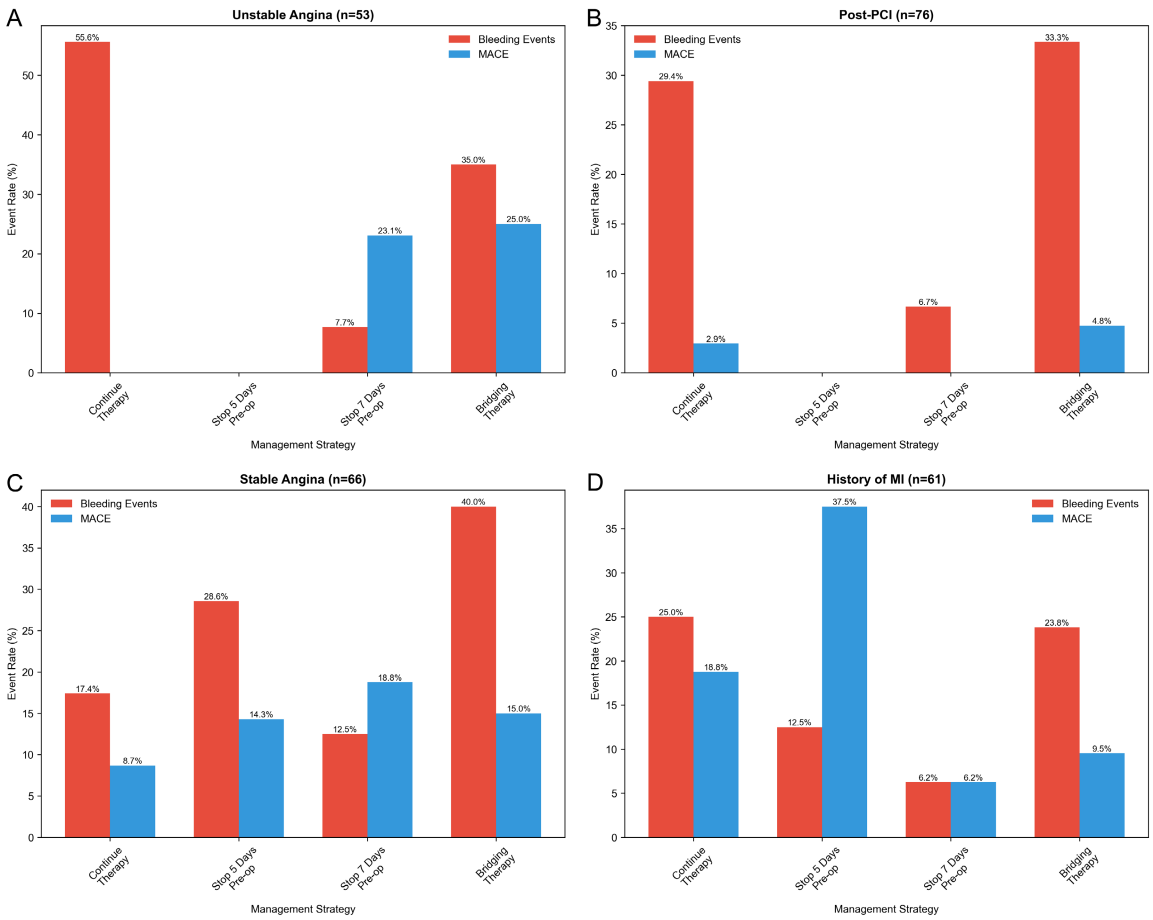

Figure 6. Subgroup analysis by CAD type. Bar graphs display bleeding (red) and MACE (blue) rates across management strategies for four CAD subtypes. Sample sizes are indicated in parentheses. A: Unstable angina (n=53): bleeding highest in Continue Therapy (55.6%) and MACE highest in Bridging Therapy (25.0%). B: Post-PCI (n=76): bleeding highest in Continue Therapy (29.4%) and Bridging Therapy (33.3%), MACE ≤4.8% in all groups. C: Stable angina (n=66): bleeding highest in Bridging Therapy (40.0%), MACE highest in Stop 7 Days Pre-op (18.8%). D: History of MI (n=61): bleeding highest in Continue Therapy (25.0%), MACE highest in Stop 5 Days Pre-op (37.5%). Abbreviations: CAD, Coronary Artery Disease; PCI, Percutaneous Coronary Intervention; MI, Myocardial Infarction.

grates thrombotic and bleeding risk assessment to guide the selection of continuation, discontinuation (5-7 days), or bridging therapy in CAD patients undergoing spinal fusion.

Discussion

This study systematically evaluated the clinical outcomes of four perioperative antiplatelet management strategies in coronary artery disease (CAD) patients undergoing spinal fusion surgery through a retrospective cohort analysis. The findings clearly reveal a core clinical dilemma: the trade-off between cardiovascular protection and bleeding risk. Specifically, the continuation strategy offered the best cardiovascular protection, with the lowest risk of major adverse cardiovascular events (MACE), but at the cost of a significantly elevated bleeding event rate (31.9%) and intraoperative blood loss (median 1,220 mL). Discontinuing antiplatelet therapy 7 days preoperatively reduced bleeding risk to the lowest level (6.7%), yet it was associated with a 3.87-fold increase in MACE risk. Bridging therapy occupied an intermediate position, achieving a relatively balanced compromise between these two opposing risks. These results provide much-needed evidence-based guidance for managing antiplatelet therapy in spinal surgery - a setting characterized by high bleeding risk.

Our findings first confirm the direct association between sustained platelet inhibition by anti-

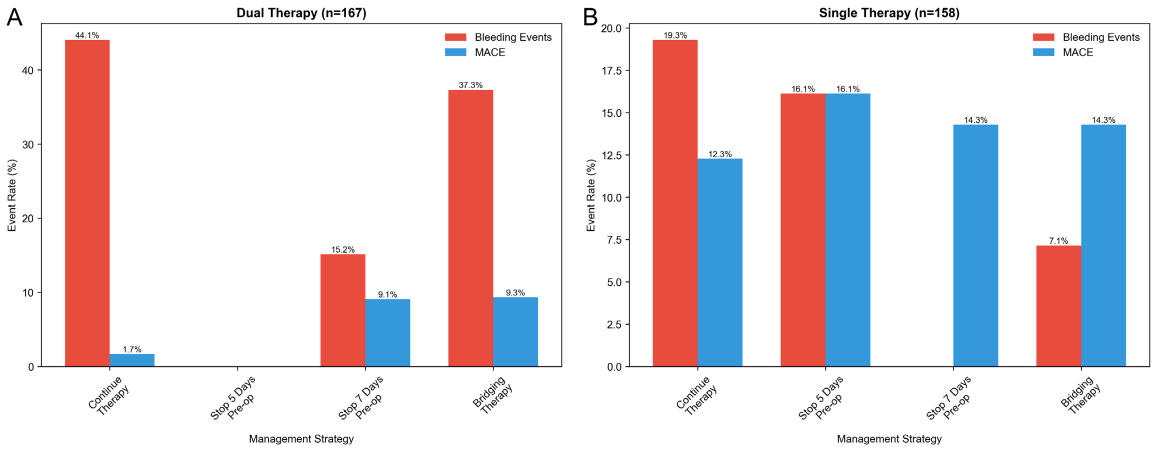

Figure 7. Subgroup analysis by antiplatelet therapy type. A: Dual therapy (n=167): Continue Therapy showed highest bleeding (44.1%) and lowest MACE (1.7%); Stop 7 Days Pre-op had bleeding 15.2% and MACE 9.1%; Bridging Therapy had bleeding 37.3% and MACE 9.3%. (No patients in the Stop 5 Days Pre-op group). B: Single therapy (n=158): Continue Therapy had bleeding (19.3%) and MACE (12.3%); Stop 5 Days Pre-op had equal rates of 16.1%; Stop 7 Days Pre-op had MACE (14.3%) with no bleeding; Bridging Therapy had bleeding (7.1%) and MACE (14.3%).

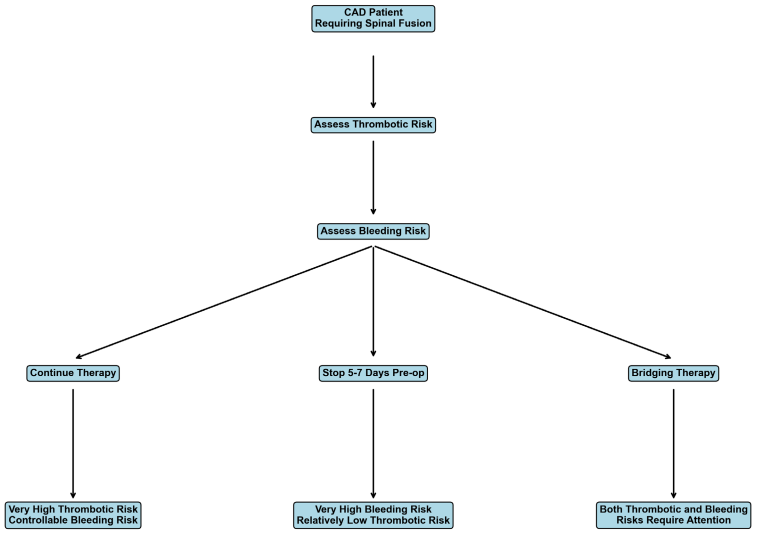

Figure 8. Clinical decision pathway for perioperative antiplatelet management in CAD patients undergoing spinal fusion. Abbreviation: CAD, Coronary Artery Disease.

platelet agents and increased perioperative bleeding risk. Spinal fusion involves extensive tissue dissection and highly vascularized cancellous bone, making hemostasis inherently challenging from a surgical standpoint [17]. The remarkably high bleeding rate (31.9%) and significantly increased transfusion requirements observed in the continuation group vividly illustrate how the antiplatelet effect is "amplified" in this specific surgical context [18]. This strongly supports the need for careful preoperative evaluation of the necessity of continuing antiplatelet therapy - particularly in patients undergoing extensive procedures (e.g., multilevel or combined anterior-posterior approaches) or those with additional bleeding risk factors - and suggests that discontinuation or bridging should be seriously considered in such cases.

In the multivariable analysis for bleeding risk, hemoglobin emerged as a statistically significant factor (OR=1.021, 95% CI 1.002-1.039, P=0.028), but the effect size is very close to unity, indicating limited clinical significance. The direction of this association - higher hemoglobin predicting greater bleeding risk - appears counterintuitive, as anemic patients are generally less tolerant of blood loss. This finding may be attributable to residual confounding: patients with higher baseline hemoglobin might have undergone more complex surgeries (e.g., multilevel fusion or revision procedures) that entail greater blood loss, a factor not fully captured in our adjustment. Alternatively, the narrow confidence interval and OR near 1 suggest this may represent a statistical artifact rather

than a true biological effect. Therefore, this result should be interpreted with caution. Diabetes (OR=0.408) and 7-day discontinuation (OR=0.128) were identified as protective factors, consistent with reduced bleeding risk in patients with diabetes and longer antiplatelet washout.

The most critical warning from our study lies in uncovering the excess cardiovascular risk associated with short-term discontinuation. Multivariate analysis confirmed that stopping antiplatelet therapy 5 days before surgery was an independent risk factor for MACE within 30 postoperative days (OR=3.36). It is important to note that the pharmacodynamic properties of different antiplatelet agents influence the interpretation of "discontinuation days". For ins-tance, clopidogrel and other $P2Y_{12}$ inhibitors require 5-7 days for platelet function recovery due to their reversible binding and gradual metabolism. In contrast, aspirin irreversibly inhibits cyclooxygenase-1 for the entire lifespan of the platelet (approximately 7-10 days), meaning that even a 5-day discontinuation may not fully restore platelet function [ref]. Therefore, the "5-day rule" primarily applies to $P2Y_{12}$ inhibitors, while aspirin discontinuation may require longer intervals to achieve hemostatic safety. This pharmacological nuance should be considered in individualized perioperative decision-making and highlights the need for future studies incorporating platelet function testing or drug-specific protocols. This aligns mechanistically with the phenomenon of platelet reactivity "rebound" that can occur after withdrawal of antiplatelet agents - particularly $P2Y_{12}$ inhibitors such as clopidogrel or ticagrelor [19-21]. Platelet function may paradoxically become hyper-reactive shortly after drug cessation, and when combined with the prothrombotic state induced by surgical trauma, this creates a pathophysiological milieu conducive to stent thrombosis and acute coronary syndromes [22, 23]. This finding has profound implications for clinical practice, as it challenges the commonly held assumption that "short-term discontinuation is relatively safe" - especially in "very high thrombotic risk" patients, such as those who received drug-eluting stents less than 12 months ago or have a history of unstable angina or myocardial infarction [24]. Our subgroup analyses further suggest that the risks of discontinuation may be even greater in these vulnerable populations. An unexpected finding was that 5-day, but not 7-day, preoperative discontinuation was independently associated with MACE. This may reflect limited statistical power in the 5-day group, unmeasured confounding (e.g., preferential allocation of higher-risk patients to longer washout), or a pharmacological phenomenon wherein platelet rebound peaks at 5-7 days, making the 5-day window particularly vulnerable [19-21]. Larger studies are needed to clarify this observation.

In this context, the value of bridging therapy becomes evident. The timing of bridging therapy initiation and discontinuation is critical to balancing thrombotic and bleeding risks. In our protocol, bridging was started 3-5 days preoperatively to ensure overlap with the waning effect of oral $P2Y_{12}$ inhibitors, thereby minimizing the "no-coverage" window. The 12-24-hour washout period for LMWH and 4-6 hours for UFH were chosen to align with surgical hemostasis requirements while maintaining antithrombotic protection as long as possible. Postoperative resumption within 24-72 hours reflects a compromise between early thrombotic prevention and the risk of surgical-site bleeding, particularly in spinal fusion where epidural hematoma is a concern. In our study, the bridging therapy group showed no statistically significant difference in cardiovascular event risk compared to the continuation group, while significantly reducing bleeding risk. This suggests that transitional use of short-acting parenteral anticoagulants (e.g., low molecular weight heparin) may theoretically maintain antithrombotic protection while allowing temporary discontinuation of oral antiplatelet agents during the critical perioperative period, thereby providing a brief "hemostatic window" for surgical control of bleeding [25-27]. However, bridging therapy is not a perfect solution - it still carries a notable bleeding risk (29.1% in our study) and requires precise timing and dosing adjustments. Current international guidelines offer inconsistent recommendations regarding bridging therapy, often based primarily on expert consensus rather than robust evidence [28, 29]. Our findings provide real-world supportive data for the cautious use of bridging therapy in high-thrombotic-risk patients undergoing spinal surgery - a procedure associated with high bleeding risk.

Based on these findings, we propose an individualized clinical decision-making pathway. This pathway emphasizes dual risk assessment as the starting point: thrombotic risk (based on CAD stability, stent type and implantation time, cardiac function, etc.) and bleeding risk (based on surgical complexity, anatomical site, comorbidities, etc.). For patients at very high thrombotic risk with manageable bleeding risk, continuing antiplatelet therapy is preferred; for those at very high bleeding risk with relatively low thrombotic risk, short-term discontinuation is favored; and for the majority of patients in whom both risks are clinically significant, bridging therapy represents a rational compromise. This structured approach aims to simplify complex decision-making and foster multidisciplinary collaboration (MDT) among cardiologists, anesthesiologists, and spine surgeons [30, 31].

This study has several limitations. First, its retrospective design is inherently susceptible to selection bias and residual confounding, despite statistical adjustment. Second, the group sizes were uneven, with a relatively small number of patients in the 5-day discontinuation group, which may affect the robustness of subgroup findings. Third, the primary endpoint was limited to short-term outcomes within 30 days, lacking long-term follow-up data on cardiovascular events or spinal fusion success. Fourth, as a single-center study, the generalizability of our conclusions requires validation through multicenter prospective research.

Conclusion

In conclusion, for CAD patients undergoing spinal fusion surgery, there is no single optimal approach to perioperative antiplatelet management; rather, the core lies in individualized risk-benefit balancing between thrombosis and bleeding. This study quantifies the risk profiles of different strategies and supports the rational application of continuation, discontinuation, or bridging therapy depending on clinical context. Future research should focus on prospective validation of optimal bridging regimens and explore precision-guided timing for drug discontinuation and resumption based on platelet function testing or genotyping, ultimately aiming to achieve the ideal perioperative goal: “neither bleeding nor thrombosis”. Future research should explore drug-specific discontinuation intervals and incorporate platelet function testing to refine perioperative management strategies.

Disclosure of conflict of interest

None.

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