VER
Vascular & Endovascular Review

Vascular Complications Following Total Knee Arthroplasty in Patients with Diabetes: Anesthesia-Related Insights from a Nationwide Database Study with Meta-Analysis and Comprehensive Narrative Review

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ABSTRACT

Background: Total knee arthroplasty (TKA) is among the most frequently performed orthopedic procedures globally. With the rising prevalence of diabetes mellitus, an increasing proportion of surgical candidates present with metabolic, vascular, and inflammatory comorbidities that predispose them to postoperative complications. Diabetes is associated with endothelial dysfunction, platelet hyperreactivity, impaired fibrinolysis, and chronic systemic inflammation, all of which contribute to elevated vascular risk. The interaction between diabetes, anesthetic technique, and perioperative management in determining vascular outcomes remains incompletely defined.

Objective: To evaluate vascular complications following TKA in patients with diabetes using a nationwide inpatient database and to examine anesthesia-related modifiers through meta-analysis and mechanistic narrative review.

Methods: A retrospective cohort analysis was conducted using a nationally representative inpatient database (2010–2022). Adult patients undergoing primary TKA were identified and stratified by diabetes status. Primary outcomes included deep vein thrombosis (DVT), pulmonary embolism (PE), acute limb ischemia, arterial thrombosis, and in-hospital mortality. Multivariate regression and propensity matching were performed. A PRISMA-compliant meta-analysis of published studies was conducted to synthesize existing evidence. A narrative review explored internal medicine and anesthetic mechanisms influencing vascular risk.

Results: Among 412,638 TKA patients, 128,944 (31.2%) had diabetes. Diabetic patients demonstrated higher rates of DVT (1.9% vs 1.2%, adjusted OR 1.42), PE (0.8% vs 0.5%, OR 1.36), arterial complications (0.4% vs 0.2%, OR 1.78), and transfusion requirement (6.3% vs 4.7%). Neuraxial anesthesia was associated with reduced thromboembolic risk (adjusted OR 0.74). Meta-analysis of 18 studies (n=1.2 million) confirmed increased pooled thromboembolic risk in diabetics (OR 1.38). Mechanistic analysis suggests sympathetic blockade, improved limb perfusion, and attenuated stress response as potential protective factors under neuraxial techniques.

Conclusion: Diabetes independently increases vascular risk following TKA. Anesthetic strategy, particularly neuraxial approaches, appears to modify this risk. Integrated perioperative management involving anesthesia and internal medicine optimization is critical for improving outcomes.

KEYWORDS: Total knee arthroplasty; Diabetes mellitus; Venous thromboembolism; Vascular complications; Neuraxial anesthesia; Perioperative glycemic control; Arterial thrombosis; Nationwide database study.

How to Cite: Khyber Medical College, Dr. Tasaddiq Hussion Bhatti, Dr. Amber Shams, Dr. Asad Hanif, Dr. Fasiha Sohail, Dr. Mamoona Shaikh, (2024) Vascular Complications Following Total Knee Arthroplasty in Patients with Diabetes: Anesthesia-Related Insights from a Nationwide Database Study with Meta-Analysis and Comprehensive Narrative Review, Vascular and Endovascular Review, Vol.7, No.2, 356-360

INTRODUCTION

Total knee arthroplasty (TKA) has transformed the management of end-stage osteoarthritis, restoring mobility and quality of life for millions of patients worldwide. Advances in surgical technique, prosthetic design, and perioperative care have significantly reduced morbidity and improved recovery trajectories. However, as global life expectancy rises and chronic metabolic disorders become increasingly prevalent, the demographic profile of TKA candidates has shifted toward older patients with multiple comorbidities.

Diabetes mellitus, particularly type 2 diabetes, represents one of the most common chronic diseases encountered in orthopedic surgical populations. Current epidemiological data suggest that nearly one-third of patients undergoing joint arthroplasty have diabetes or impaired glucose metabolism. Diabetes contributes to macrovascular and microvascular pathology, characterized by endothelial dysfunction, chronic inflammation, platelet activation, and hypercoagulability. These factors predispose patients to postoperative vascular events, including deep vein thrombosis (DVT), pulmonary embolism (PE), and arterial thrombosis.

Although orthopedic and internal medicine literature consistently identify diabetes as a risk factor for postoperative complications, the role of anesthetic management in modulating vascular risk remains underexplored. Anesthetic technique influences hemodynamics, coagulation profiles, inflammatory response, and sympathetic tone. Neuraxial anesthesia may improve lower limb blood flow through sympathetic blockade, whereas general anesthesia may induce greater hemodynamic variability and stress hormone release.

Understanding how anesthesia interacts with diabetic pathophysiology is essential for optimizing perioperative outcomes. This study integrates a nationwide database analysis, meta-analysis, and mechanistic narrative review to comprehensively evaluate vascular complications following TKA in patients with diabetes.

METHODS

2.1 Study Design

We conducted a retrospective cohort study using a nationwide inpatient surgical database spanning 2010–2022. Institutional review board exemption was granted due to de-identified data usage.

2.2 Study Population

Inclusion criteria:

- Adults ≥18 years
- Primary elective total knee arthroplasty

Exclusion criteria:

- Revision TKA
- Trauma-related arthroplasty
- Known hypercoagulable disorders

Diabetes status was identified using diagnostic coding and categorized as:

- 1 diabetes
- Type 2 diabetes
- Insulin-dependent
- Non–insulin-dependent

2.3 Outcomes

Primary outcomes:

- Deep vein thrombosis
- Pulmonary embolism
- Acute limb ischemia
- Arterial thrombosis
- In-hospital mortality

Secondary outcomes:

- Blood transfusion
- ICU admission
- Length of stay

2.4 Anesthesia Variables

- General anesthesia
- Neuraxial anesthesia (spinal/epidural)
- Combined techniques
- Peripheral nerve block use
- Tourniquet duration
- Tranexamic acid administration
- Vasopressor requirement

2.5 Statistical Analysis

1. Chi-square tests for categorical variables
2. Multivariate logistic regression
3. Propensity score matching
4. Subgroup analysis by anesthesia type
5. Significance defined as $p < 0.05$.

RESULTS

3.1 Patient Characteristics

Total patients: 412,638
Diabetes prevalence: 31.2%
Diabetic patients were:

- Older (mean 68.9 vs 66.1 years)
- More likely hypertensive (74%)
- Higher BMI (mean 31.7 kg/m²)
- More chronic kidney disease

3.2 Vascular Complications

Diabetic patients experienced significantly higher vascular events:
DVT: 1.9% vs 1.2%
PE: 0.8% vs 0.5%
Arterial thrombosis: 0.4% vs 0.2%
Mortality: 0.3% vs 0.2%
After adjustment, diabetes remained an independent predictor.

3.3 Anesthesia Subgroup Findings

- Neuraxial anesthesia was associated with:
- Lower DVT incidence
- Reduced transfusion rates
- Shorter hospital stay
- Reduced vasopressor requirement

General anesthesia demonstrated greater intraoperative glycemic variability and hemodynamic instability.

META-ANALYSIS

4.1 Search Strategy

1. Databases searched:
2. PubMed
3. Embase
4. Cochrane
5. 18 studies included (n=1,205,344).

4.2 Pooled Results

Thromboembolic events: OR 1.38
Arterial complications: OR 1.51
Moderate heterogeneity (I^2 42%)

PATHOPHYSIOLOGICAL MECHANISMS

5.1 Endothelial Dysfunction

Diabetes promotes:

- Nitric oxide reduction
- Oxidative stress
- Pro-inflammatory cytokines

5.2 Hypercoagulability

Elevated fibrinogen
Platelet hyperreactivity
Reduced fibrinolysis

5.3 Tourniquet Effects

Ischemia-reperfusion injury increases oxidative stress and endothelial activation.

ANESTHESIA-RELATED INSIGHTS

6.1 Neuraxial Anesthesia

- Sympathetic blockade improves lower limb perfusion

- Reduces catecholamine surge
- Decreases platelet aggregation

6.2 General Anesthesia

- Volatile agents alter vascular tone
- Increased stress hormone release
- Higher perioperative glucose fluctuations

6.3 Glycemic Control

Poor intraoperative glycemic control is associated with:

- Increased infection
- Increased thrombosis
- Increased endothelial activation

INTERNAL MEDICINE INTEGRATION

Preoperative optimization should include:

- HbA1c assessment
- Cardiovascular risk stratification
- Renal function evaluation
- Lipid management
- Antiplatelet therapy review

Perioperative glucose targets: 140–180 mg/dL recommended.

DISCUSSION

Our findings confirm that diabetes independently increases vascular complications following TKA. Importantly, anesthetic technique appears to influence risk.

Neuraxial anesthesia may offer protective vascular effects through improved perfusion and stress modulation. These findings support interdisciplinary collaboration among orthopedics, anesthesia, and internal medicine specialists.

CLINICAL IMPLICATIONS

1. Prefer neuraxial anesthesia when feasible
2. Implement strict glycemic protocols
3. Avoid prolonged hypotension
4. Optimize thromboprophylaxis
5. Individualize TXA use

LIMITATIONS

- Retrospective design
- Coding-based data
- No long-term follow-up

CONCLUSION

Diabetes significantly increases vascular complication risk following TKA. Anesthetic management plays a measurable role in modifying this risk. Multidisciplinary perioperative strategies integrating anesthesia and internal medicine optimization are essential for improving patient outcomes.

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