

# Periarticular Vasoconstrictor Infiltration in a Tourniquet-Free Total Knee Arthroplasty: A Case Report of Effective Blood Loss Control in High-Thrombotic-Risk Patient

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**Abstract:** Effective perioperative pain control is essential in Total Knee Arthroplasty (TKA) to support early mobilization and enhance recovery, particularly within Enhanced Recovery After Surgery (ERAS) protocols. The use of a thigh tourniquet, although common, is increasingly questioned due to its association with postoperative pain and thromboembolic risk, especially in patients with a history of Deep Vein Thrombosis (DVT). Periarticular Vasoconstrictor Infiltration (PVI) is a recently described technique aimed at achieving localized hemostasis through epinephrine-based infiltration. This case report illustrates the clinical utility of ultrasound-guided PVI as part of a multimodal, tourniquet-free strategy in high-risk patient. A 66-year-old female with severe right knee osteoarthritis and a history of right lower limb DVT underwent primary TKA under spinal anesthesia. Due to the patient's elevated thrombotic risk—defined by a high Caprini score—a tailored regional anesthesia protocol was adopted, combining multi-target PVI with a proximal adductor canal block and spinal anesthesia. The PVI solution included ropivacaine, dexmedetomidine, and epinephrine. No tourniquet was inflated during the procedure. The surgical field remained bloodless throughout the 72-minute procedure. Intraoperative blood loss was less than 200 mL, and no transfusion was required. Postoperative analgesia was effective, opioid use was minimized, and the patient mobilized the same evening without complications. No clinical or ultrasound signs of early postoperative thrombotic events were observed. This case demonstrates the feasibility and clinical benefit of integrating ultrasound-guided PVI into a multimodal, tourniquet-free anesthetic strategy for TKA in high-thrombotic-risk patients. The approach provided effective analgesia and hemostasis, aligned with ERAS principles, and may represent a valuable alternative for personalized perioperative care in orthopedic surgery.

**Keywords:** total knee arthroplasty, TKA, free-tourniquet, periarticular vasoconstrictor infiltration, case report, nerve block

## Introduction

Effective perioperative pain management is essential in Total Knee Arthroplasty (TKA) to ensure optimal surgical outcomes and support early mobilization, as advocated by Enhanced Recovery After Surgery (ERAS) protocols.<sup>1,2</sup> A significant contributor to perioperative pain in TKA is the use of a thigh tourniquet—a practice increasingly questioned due to its associated risks, particularly in patients with a history of Deep Vein Thrombosis (DVT).<sup>3</sup> Although traditionally used to optimize visualization and facilitate prosthesis placement by creating a bloodless field, tourniquet application carries several drawbacks, including a higher incidence of thromboembolic events, postoperative thigh pain, delayed recovery, and potential nerve and muscle injury.<sup>4–7</sup>

Postoperative pain after TKA stems from the complex innervation of the knee joint, which involves both anterior and posterior neural pathways.<sup>8</sup> To address this multifaceted pain origin while preserving motor function, modern regional anesthesia strategies have emerged—such as the Adductor Canal Block (ACB), Genicular Nerve Block (GNB), and the Infiltration between the Popliteal Artery and the Capsule of the Knee (IPACK).<sup>9–13</sup>

While the regional anesthesia techniques listed above primarily aim to provide analgesia and preserve motor function, intraoperative hemostasis relies on distinct strategies. Traditionally, hemostasis during TKA has been achieved with a thigh tourniquet or pharmacologic agents such as tranexamic acid.<sup>2</sup> However, concerns regarding tourniquet-related pain, ischemia–reperfusion injury, and thromboembolic complications have encouraged the development of alternative, tourniquet-free methods.<sup>3–6</sup> This perspective is supported by recent meta-analyses showing that tourniquet use during TKA may increase postoperative pain, impair early functional recovery, and elevate thromboembolic risk, even in patients without recognized prothrombotic conditions.<sup>14–16</sup> These findings suggest that alternative hemostatic strategies may be beneficial across a broad patient population. Within this evolving context, Periarticular Vasoconstrictor Infiltration (PVI) represents a novel hemostatic approach that relies on localized chemical vasoconstriction. The PVI technique, recently described by Vicente Roques, represents a new means of achieving intraoperative hemostasis through localized vasoconstriction by injecting diluted epinephrine into periarticular tissues.<sup>17</sup> In the present case, this approach was expanded by combining epinephrine with ropivacaine and dexmedetomidine, thereby providing both hemostatic control and effective analgesia.

By integrating this multi-target PVI protocol—guided by Ultrasound (US) and performed without a tourniquet—alongside Spinal Anesthesia (SA), we hypothesized that combining US-guided PVI with a multimodal regional anesthesia protocol could help maintain a bloodless operative field, enhance perioperative analgesia, and support early mobilization in patients for whom tourniquet use may pose additional thrombotic risk. This combination aligns with contemporary goals of opioid-sparing analgesia and personalized perioperative care, demonstrating the potential of tailored anesthetic techniques in complex orthopedic settings. The purpose of this case report is to describe a personalized anesthetic strategy for Total Knee Arthroplasty in a high-thrombotic-risk patient, using a multimodal, tourniquet-free protocol based on PVI. To our knowledge, no previous case reports have described the use of PVI as a primary hemostatic strategy in tourniquet-free TKA, making this the first detailed clinical application of the technique in knee arthroplasty. The goal of this case report is to describe the perioperative application of ultrasound-guided PVI within a multimodal, tourniquet-free strategy for TKA, and to illustrate its potential role in integrating hemostatic and analgesic objectives in alignment with ERAS principles.

## Case Report

The patient consented to the use of personal data in the publication of this report for scientific and clinical purposes. Ethics committee approval was not required for this retrospective study, as it involved the analysis of data obtained during routine clinical practice.

A 66-year-old female (BMI 38.3 kg/m<sup>2</sup>; weight, 104 kg; height, 165 cm) with severe right knee osteoarthritis was scheduled for primary TKA at our institution (Isola Tiberina Hospital, Gemelli Isola, Rome) (Figure 1). The patient's medical history included Hypertension, Class II Obesity, Chronic Obstructive Pulmonary Disease (COPD), Hypercholesterolemia, no known drug allergies and a prior DVT of the right lower limb diagnosed nine months earlier.

During the preoperative anesthesiology evaluation, the patient showed no clinical signs of DVT. A bilateral lower limb color Doppler ultrasound was negative for new thrombi. Following the previous DVT episode, the patient underwent laboratory screening for thrombophilia, including genetic testing, all of which returned negative. An American Society of Anesthesiologists Physical Status (ASA-PS) of grade III was assigned to the patient. At our institution, preoperative thrombotic risk is routinely assessed using the Caprini Score, a validated and widely adopted tool with strong applicability in orthopedic and arthroplasty populations.<sup>18</sup> In this case, the patient had a Caprini Score of 12, corresponding to an “extremely high risk” of venous thromboembolism. Contributing factors included age (66 years), obesity (BMI 38.3 kg/m<sup>2</sup>), previous ipsilateral DVT, elective TKA as a major lower-limb orthopedic procedure, and COPD. Elastic compression stockings were prescribed preoperatively as part of thromboembolism prophylaxis.



**Figure 1** Preoperative lateral radiograph of the right knee under weight-bearing conditions (SOTTO CARICO) demonstrating severe osteoarthritis with joint space narrowing and osteophytic formation. The vertical measurement indicates the planned tibial bone cut for prosthetic alignment (83.4 mm projection).

In light of this markedly elevated thrombotic risk profile, the multidisciplinary team deemed the use of a tourniquet inadvisable. These factors collectively reflect commonly accepted indicators of elevated perioperative thrombotic risk in major lower-limb orthopedic surgery and warrant modification of the standard institutional anesthetic protocol. The usual protocol includes SA with an ACB and local infiltration analgesia (LIA) into the posterior capsule. Instead, a modified regional anesthesia approach was adopted, incorporating PVI to help limit intraoperative blood loss, in combination with a proximal ACB and SA.

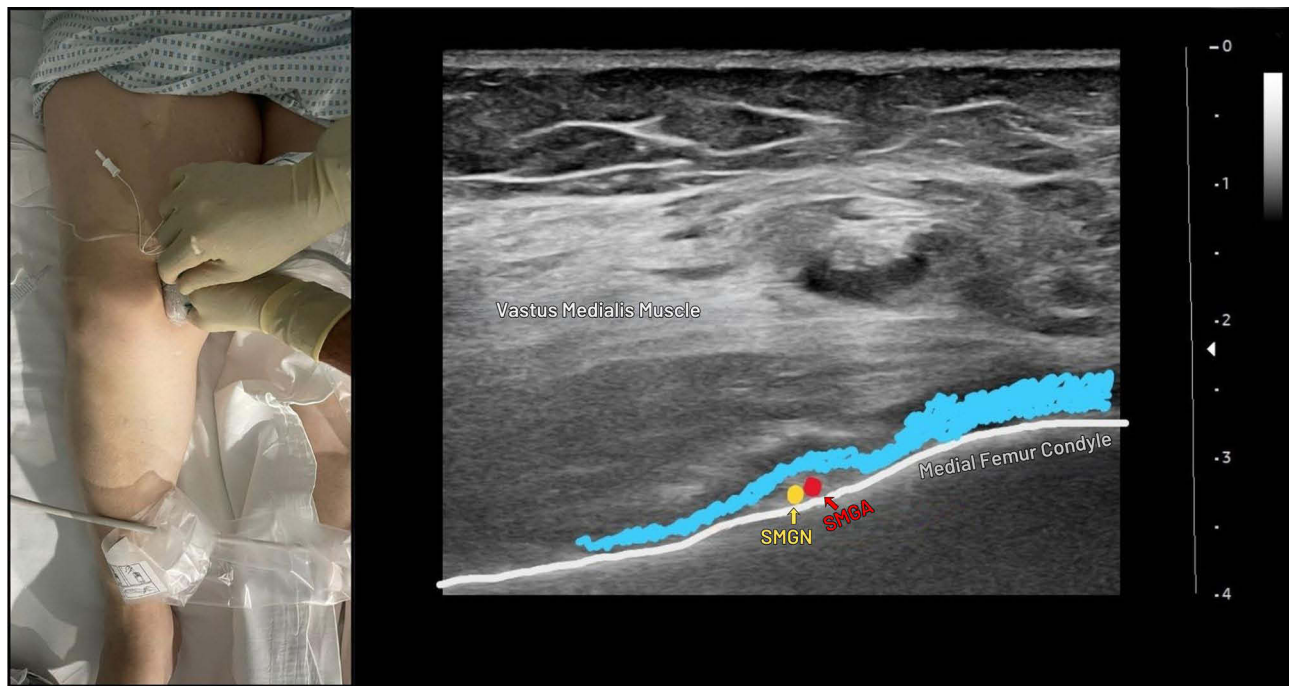
In the preoperative holding area, the patient was positioned supine. An 18G IV line was placed in the non-operative arm. Standard monitoring was applied with continuous electrocardiogram, noninvasive blood pressure and pulse oximetry. Antiemetic (8 mg Ondansetron IV) and antibiotic (2 g Cefazolin IV) prophylaxis was administered. Pre-procedural sedation was achieved with Midazolam 2 mg and Fentanyl 25 mcg intravenously.

All blocks were always preceded by meticulous skin disinfection with 2% chlorhexidine in 70% isopropyl alcohol and were performed by an anesthesiologist experienced in US-guided regional anesthesia.

The US-guided PVI technique consisted of injecting a 0.9% NaCl solution containing Ropivacaine 0.1%, Dexmedetomidine (0.375 µg/mL), and Epinephrine (1:200,000). Injections targeted the superomedial, superolateral, and inferomedial genicular nerves, the anterior knee (specifically the peripatellar tendon area near to the surgical incision), and the posterior capsule through an IPACK block.

For GNB the patient was positioned supine with the operative leg slightly externally rotated. A high-frequency linear probe (Samsung HS50) was placed in the long axis of the knee in a coronal plane. A 100-mm, 20-gauge, 30° tip needle (Stimuplex® Ultra 360®, B. Braun) was inserted using an out-of-plane approach. Three periarticular target regions were identified: the superior medial, superior lateral, and inferior medial genicular arteries.

For the Superior Medial Genicular Nerve (SMGN), the probe was placed over the medial femoral epicondyle and moved proximally to visualize the superior medial genicular artery. The needle was then advanced until bone contact was achieved (Figure 2). To target the Superior Lateral Genicular Nerve (SLGN), the probe was positioned over the lateral



**Figure 2** Left side: Ultrasound probe positioned over the distal medial femoral shaft with an out-of-plane approach for PVI targeting the SMGN. Right side: Ultrasound landmarks and target for PVI targeting the SMGN. The white line delineates the medial femoral condyle and the femoral shaft; the yellow circle identifies the superomedial genicular nerve (SMGN), highlighted by a yellow arrow; the red circle marks the superomedial genicular artery (SMGA), indicated by a red arrow; and the light-blue shading illustrates the spread of the injectate along the periosteum enveloping the target structures.

femoral condyle and advanced proximally to visualize either the superior lateral genicular artery or the deepest portion of the vastus lateralis (Figure 3). The Inferior Medial Genicular Nerve (IMGN) was approached by positioning the probe over the medial tibial plateau and moving distally until the tibial metaphysis, where the inferior medial genicular artery was located (Figure 4). Each site was infiltrated with 20 mL of the prepared solution.

Using an in-plane approach at the same decubitus, an additional 30 mL of the same solution was injected along the anterior surgical incision, including subcutaneous tissues innervated by the anterior cutaneous branches of femoral nerve (Figure 5).

A standard IPACK block was performed with the patient in the supine position and the operative knee slightly flexed, using an in-plane approach to inject 20 mL of the same solution between the popliteal artery and the posterior capsule of the knee (Figure 6).

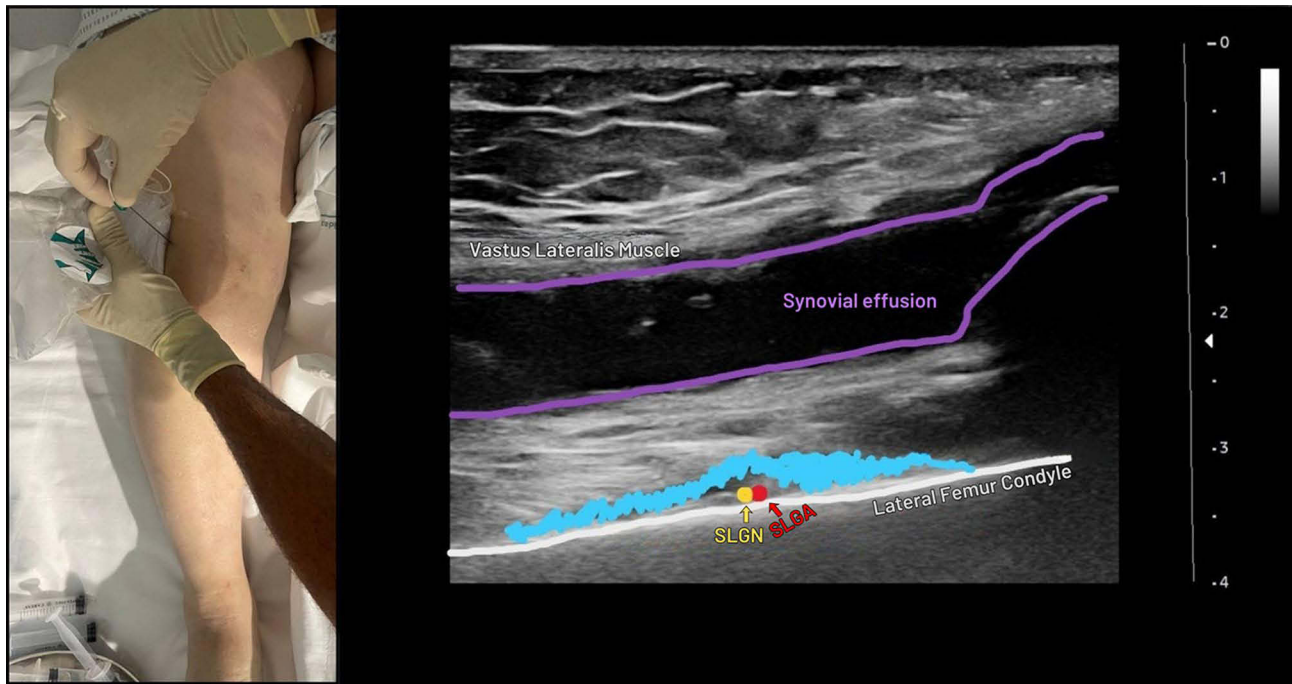
Subsequently, a proximal US-Guided ACB was performed using 20 mL of Ropivacaine 0.3% with Dexmedetomidine 15 mcg (Figure 7).

After confirming local tumescence, the patient was transferred to the operating room. SA was administered using a 25G Whitacre needle, with intrathecal injection of 10 mg of 0.5% Hyperbaric Bupivacaine and 2 mcg of Sufentanil (Figure 8A). A tourniquet was placed prophylactically but remained deflated throughout the surgery (Figure 8B).

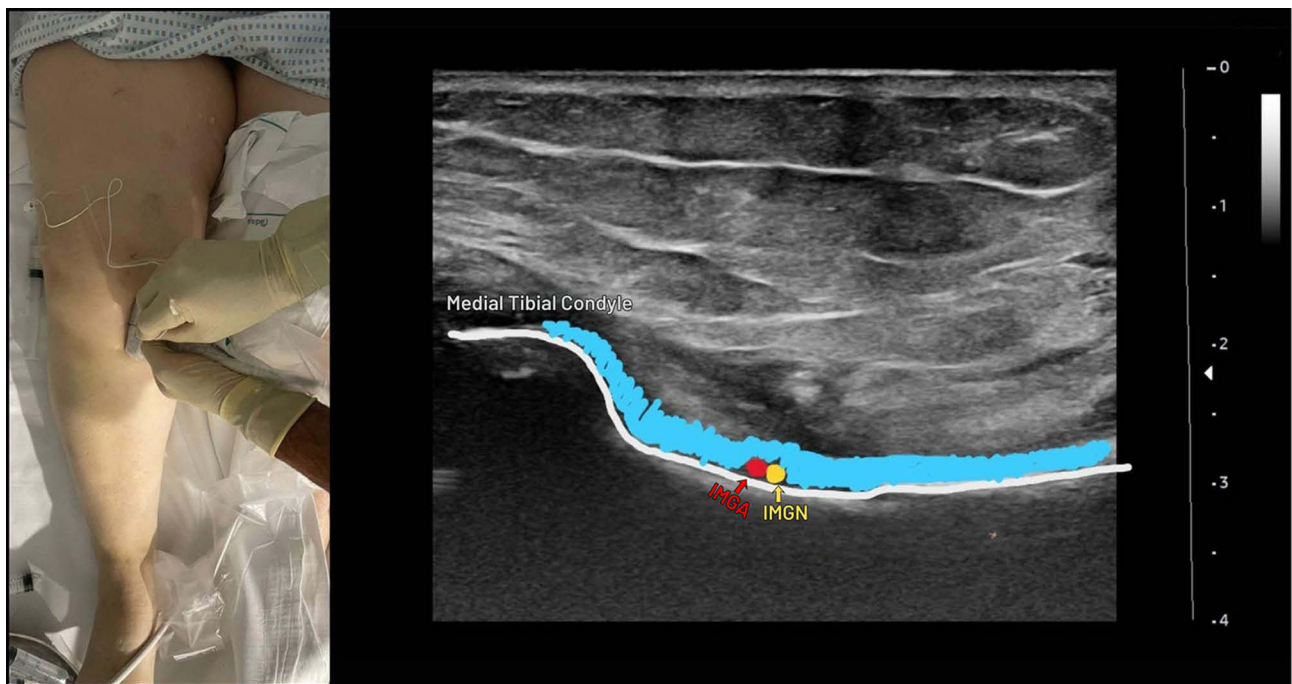
At the conclusion of the anesthetic procedures, motor and sensory blocks were evaluated using the Bromage scale and the Hollmen scale, respectively. An adequate anesthetic plane was achieved, with complete motor block (Bromage score 1) and sensory block confirmed by pinprick and ice tests (Hollmen scale 4).

The surgical procedure lasted 72 minutes, during which the field remained bloodless, with a total blood loss of less than 200 mL (Figure 9A–F). See [Video S1](#) demonstrating the tourniquet-free TKA with a bloodless surgical field.

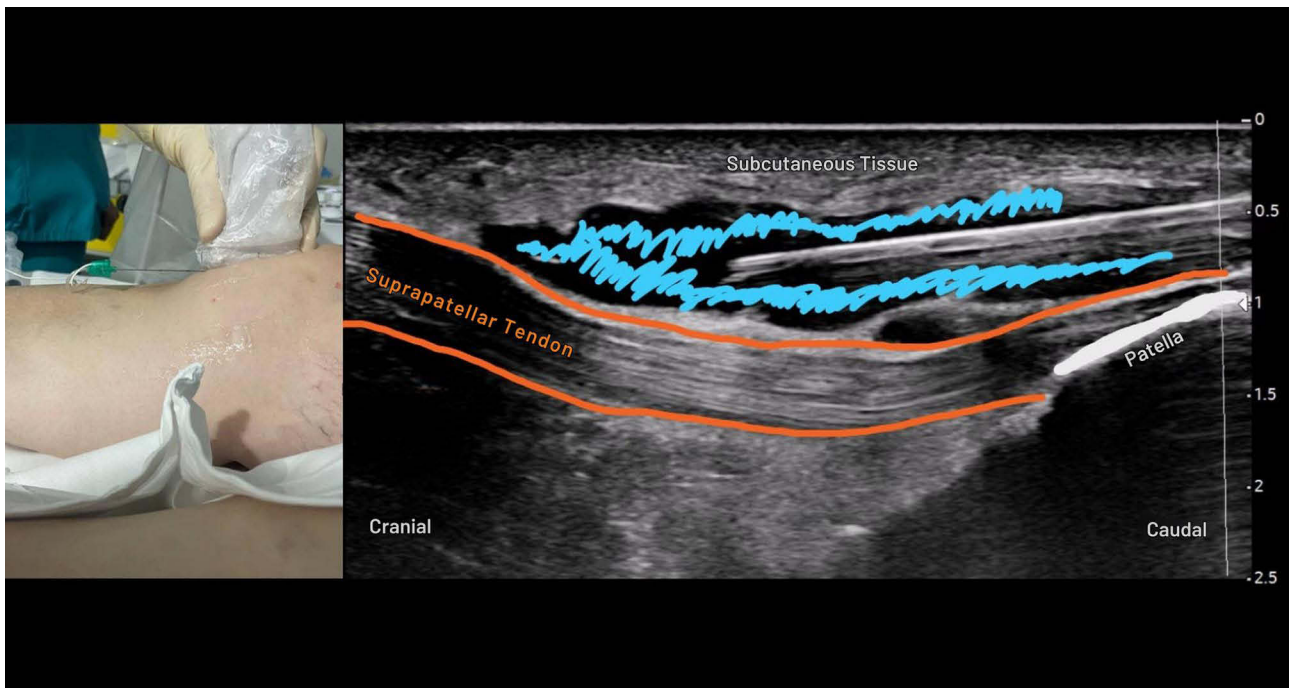
The patient remained hemodynamically stable throughout. Postoperative analgesia consisted of Paracetamol 1 g three times daily alternating with Ketoprofen 30 mg three times daily. Pain was assessed using the Numerical Rating Scale (NRS) at 24 hours postoperatively. Rescue opioid analgesia with Oxycodone (up to 0.1 mg/kg) was prescribed in case of NRS  $\geq 4$ , but it was not needed.



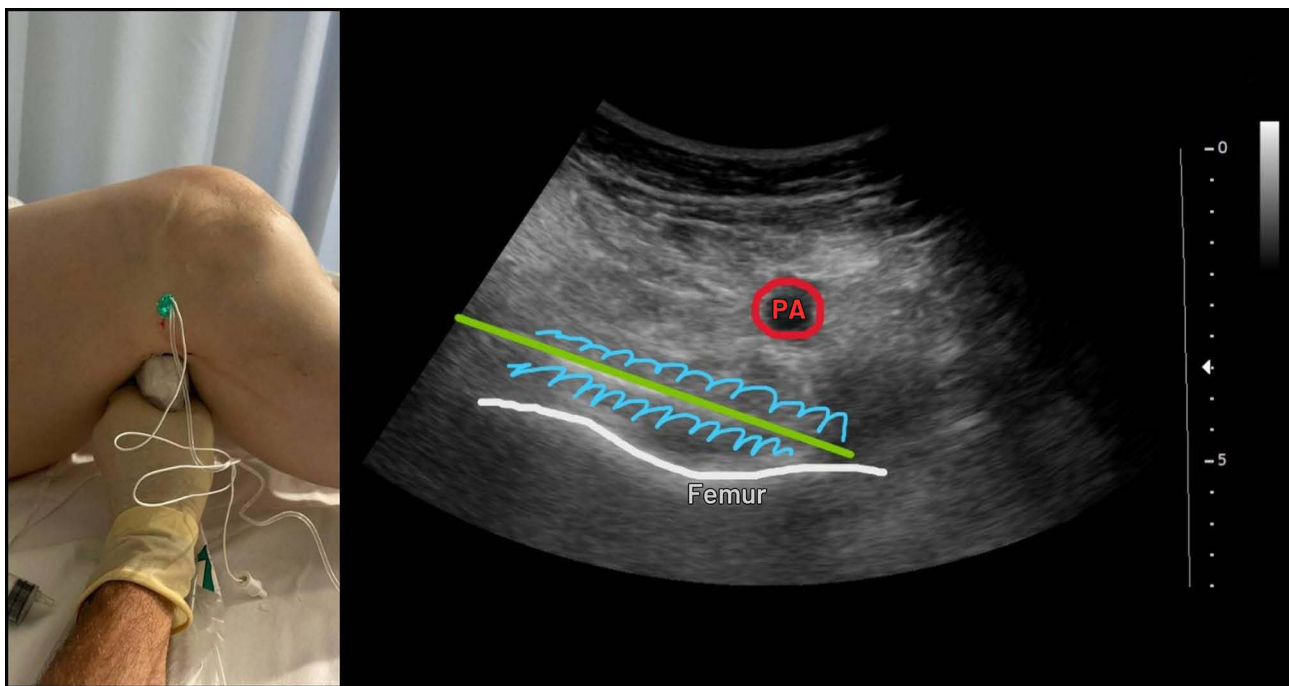
**Figure 3** Left side: Ultrasound probe positioned over the distal lateral femoral shaft with an out-of-plane approach for PVI targeting the SLGN. Right side: Ultrasound landmarks and target for PVI targeting the SLGN. The white line outlines the lateral femoral condyle; the yellow circle highlights the superolateral genicular nerve (SLGN), indicated by a yellow arrow; the red circle marks the superolateral genicular artery (SLGA), indicated by a red arrow; and the light-blue shading represents the expected spread of the injectate along the periosteum. A synovial effusion, bordered between the purple lines, is also visible adjacent to the joint capsule. The vastus lateralis muscle is also visualized in its anatomical position, lying superficially relative to the deeper target structures.



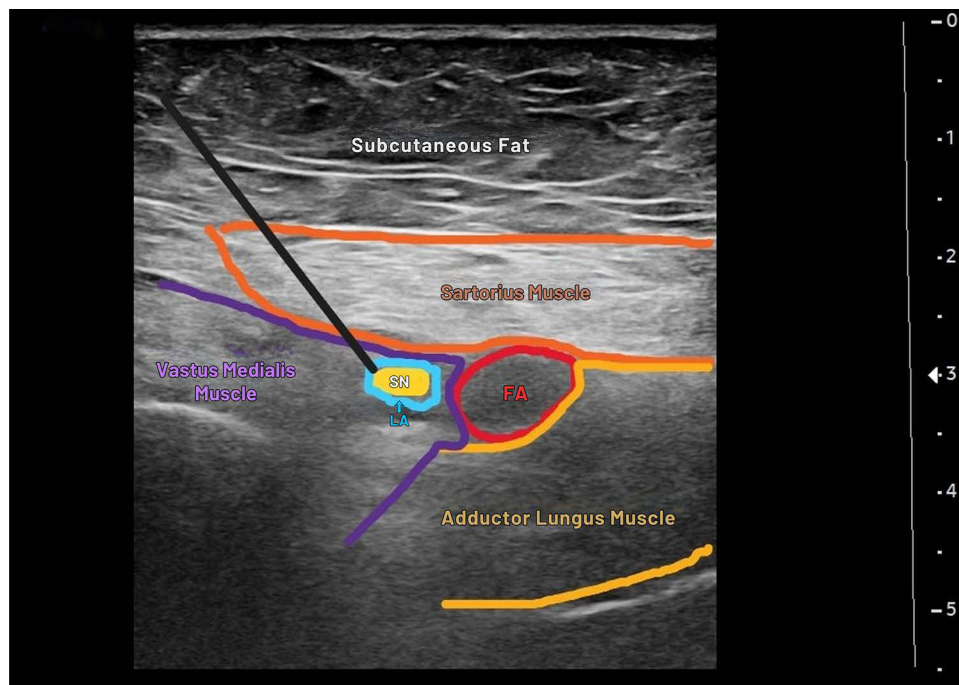
**Figure 4** Left side: Ultrasound probe positioned over the proximal medial tibial shaft with an out-of-plane approach for PVI targeting the IMGN. Right side: Ultrasound landmarks and target for PVI targeting the IMGN. The white line delineates the medial tibial condyle; the yellow circle identifies the inferomedial genicular nerve (IMGN), indicated by a yellow arrow; the red circle marks the inferomedial genicular artery (IMGGA), highlighted by a red arrow; and the light-blue shading represents the spread of the injectate surrounding the targeted structures.



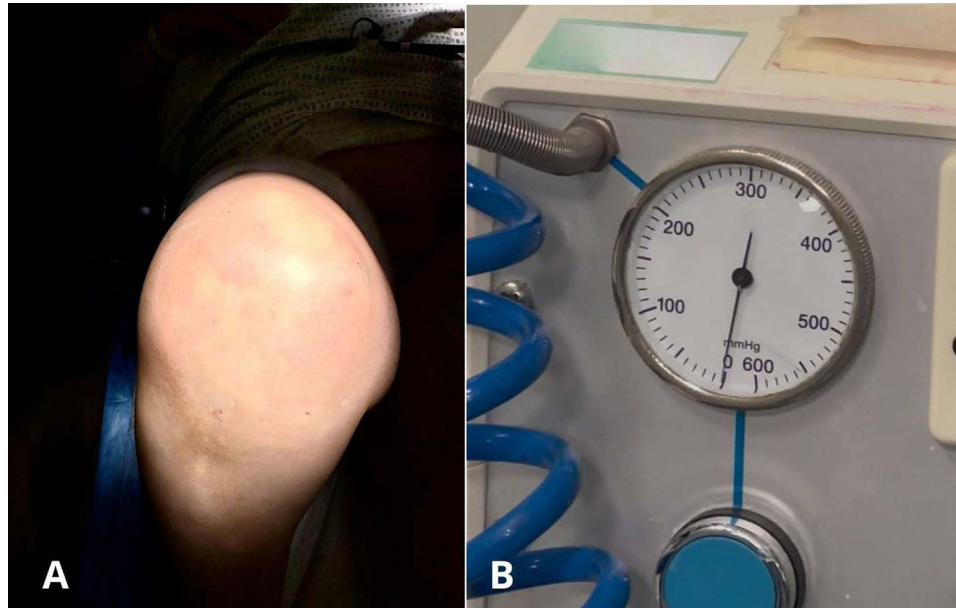
**Figure 5** Left side: Ultrasound probe positioned over the anterior surface of the knee, corresponding to the surgical incision site, using an in-plane approach for PVI targeting the peripatellar tendon region. Right side: Ultrasound landmarks and target for PVI targeting the peripatellar tendon region. The white line outlines the patella, while the area delimited by the two Orange lines corresponds to the suprapatellar tendon. Beneath the subcutaneous tissue, a hyperechoic block needle is visualized advancing in a caudo-cranial direction; the light-blue shading represents the spread of the injectate, which dissects the plane between the subcutaneous fat and the suprapatellar tendon.



**Figure 6** Left side: Ultrasound probe positioning to scan the popliteal region and perform an IPACK block with in-plane approach. Right side: Ultrasound landmarks and target for IPACK block. The white line outlines the femoral condyle; the red circle marks the popliteal artery (PA); and the green line depicts the block needle advancing within the IPACK plane between these two structures. The light-blue shading shows the distribution of the injectate spreading between the femur and the popliteal artery.

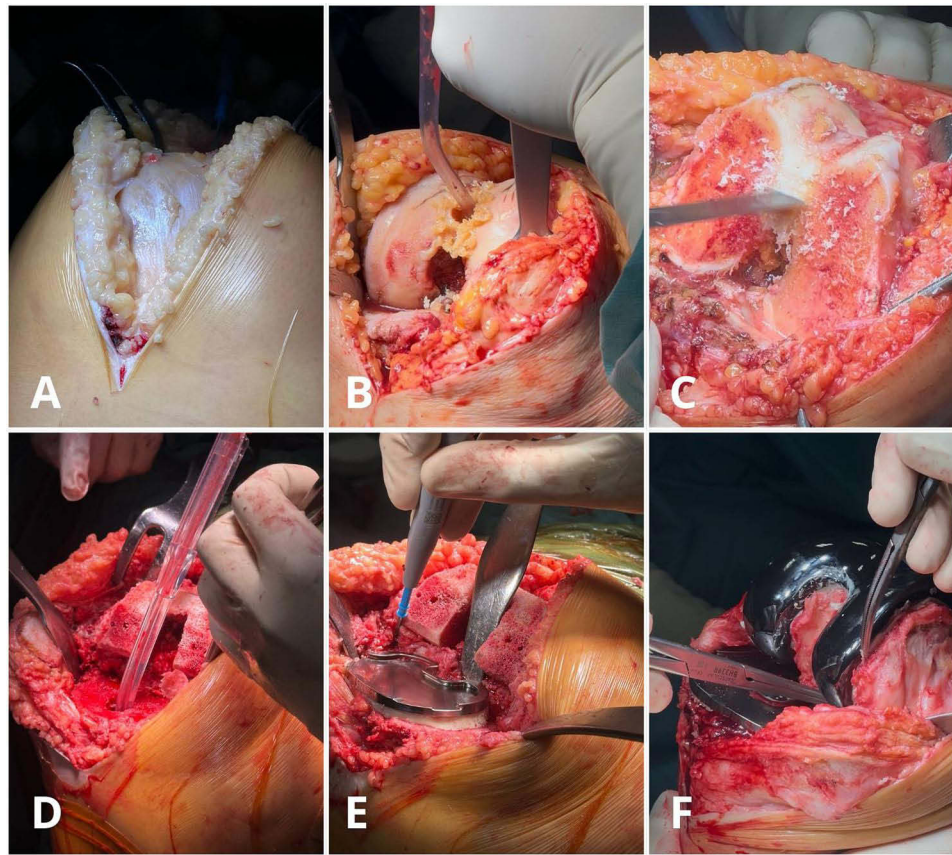


**Figure 7** Ultrasound landmarks and target for Proximal ACBN. The image depicts the proximal portion of the adductor canal, where the aponeuroses of the sartorius and adductor longus muscles converge. Superficially, the subcutaneous adipose tissue is visualized. Deep and medially, the sartorius muscle is identified, delineated by the dark-Orange lines, with the femoral artery (FA) lying immediately beneath it and marked by the red circle. Laterally, the vastus medialis muscle is observed and outlined by the purple line. Posteriorly, the adductor longus muscle is seen, demarcated by the light-orange line. The black line represents the trajectory of the block needle advancing with an in-plane latero-medial approach toward the saphenous nerve (SN), highlighted by the yellow circle. A light-blue circular outline depicts the spread of local anesthetic (LA) surrounding the nerve, as indicated by the light-blue arrow.



**Figure 8** (A) Preoperative right knee image showing local tumescence after peripatellar tendon region PVI. (B) Thigh tourniquet placed but left deflated throughout the procedure.

The patient was mobilized on the same evening, reported no pain or vasovagal symptoms and expressed high satisfaction with the analgesic regimen. Estimated blood loss was approximately 0.2 L, calculated with Meunier formula,<sup>19</sup> and no transfusion was needed. Postoperative thromboprophylaxis included the use of graduated compression stockings worn continuously for the first 72 hours and then during daytime ambulation for 10 days. Early mobilization



**Figure 9** Different phases of Tourniquet-Free TKA (A) Surgical incision through the subcutaneous layers. (B and C) Preparation and exposure of the femoral surface. (D) Preparation and exposure of the tibial surface. (E) Implantation of the cemented tibial component. (F) Implantation of the cemented femoral component.

was encouraged beginning the evening of surgery, with assisted walking every 2–3 hours during daytime. A standardized physiotherapy program was initiated on postoperative Day 1, consisting of quadriceps-setting exercises, ankle-pumping drills, and passive-assisted knee flexion. In-bed intermittent pneumatic compression devices were applied for the first 24 hours, in accordance with institutional protocol. The total length of hospital stay was 3 days, which was consistent with our institution’s ERAS-based fast-track protocol for primary TKA. The patient was discharged with Low-Molecular-Weight Heparin (LMWH) for thromboembolic prophylaxis and advised to attend follow-up visits at 1 and 6 months postoperatively. At both follow-up evaluations, no signs or symptoms of thrombotic events was reported.

## Discussion

This case report presents the first detailed clinical application of PVI as a primary hemostatic strategy in tourniquet-free TKA. While previous literature has described the technique only in preliminary or theoretical terms, our report demonstrates its practical feasibility, and its potential advantages in a high-thrombotic-risk patient. By combining US-guided PVI with a multimodal regional anesthesia protocol—including a proximal ACB and an IPACK block—we achieved excellent intraoperative hemostasis and analgesia, allowing for a bloodless surgical field and early mobilization—all in alignment with ERAS protocols.<sup>1,2</sup>

Our findings align with and expand upon the technique introduced by Roques et al in 2022, who first described PVI as a novel method of achieving chemical vasoconstriction in orthopedic surgery through epinephrine-based infiltration of periarticular tissues.<sup>17</sup> In our case, we adapted this technique by incorporating dexmedetomidine and ropivacaine to enhance analgesic efficacy and prolong duration of action, thus extending the applicability of PVI from experimental to practical clinical use in high-risk scenarios.

The role of the tourniquet in TKA has been increasingly debated due to concerns over postoperative pain, muscle damage, delayed recovery, and especially thromboembolic complications. Multiple studies—including those by Mori et al and Huang et al—have demonstrated that tourniquet use in TKA is associated with a hypercoagulable state and increased risk of distal DVT.<sup>3,20</sup>

Additionally, our approach aligns with recent literature supporting tourniquet-free TKA. For example, Tan et al and Albayrak et al reported that performing TKA without a tourniquet, when combined with proper hemostatic techniques, does not increase blood loss and may even reduce complication rates.<sup>6,7</sup> These findings reinforce growing concerns that tourniquet use may not be benign in certain subgroups of patients and raise the possibility that alternative hemostatic methods—such as pharmacologic or ultrasound-guided periarticular approaches—may offer comparable visualization without amplifying coagulation activation. Further prospective studies are needed to clarify whether replacing or minimizing tourniquet use could lead to measurable reductions in postoperative thrombotic complications, particularly in high-risk populations. In our case, total intraoperative blood loss remained below 200 mL, and no transfusion was required. This value compares favorably with reports of tourniquet-free TKA in the literature, where typical intraoperative losses range from 300–500 mL even with standard hemostatic measures.<sup>14–16</sup> Such comparison supports the potential contribution of PVI to achieving effective chemical hemostasis.

The integration of dexmedetomidine in our anesthetic mixture is supported by several studies demonstrating its role as an effective adjuvant in peripheral nerve blocks. Dexmedetomidine has been shown to prolong sensory block, enhance analgesia, and reduce the need for opioids postoperatively.<sup>21–23</sup> This pharmacologic synergy likely contributed to our patient's excellent analgesic profile, early mobilization, and avoidance of rescue opioids.

From an anatomic standpoint, the PVI technique allowed targeted infiltration around the superomedial, superolateral, and inferomedial genicular arteries—key vascular structures intimately associated with the articular nerve branches. This targeted chemical vasoconstriction, combined with selective sensory block, provided effective hemostasis and analgesia while preserving motor function—an essential goal in ERAS-aligned, motor-sparing regional anesthesia.<sup>1,2,24</sup>

The relevance of aligning this approach with ICAROS recommendations lies in the fact that these guidelines represent the leading international consensus on perioperative anesthesia in major orthopedic surgery. They emphasize multimodal, motor-sparing, and opioid-sparing strategies that support early mobilization and reduce perioperative morbidity—principles that are particularly important in tourniquet-free TKA.<sup>10,24</sup> Integrating PVI within an US-guided regional anesthesia protocol is therefore fully consistent with this framework, illustrating how an innovative hemostatic technique can complement modern multimodal anesthesia and enhance patient-centered fast-track recovery.

The PVI technique offers a promising tourniquet-free strategy that achieves both hemostasis and analgesia by targeting key periarticular neurovascular structures. The anterior capsule of the knee is innervated by branches of the femoral nerve (nerve to vastus medialis/lateralis/intermedius, saphenous nerve), the anterior cutaneous branches of femoral nerve, sciatic nerve (via common peroneal and genicular branches), and the anterior division of the obturator nerve. Posteriorly, articular branches derive from the posterior obturator and sciatic nerves (tibial and peroneal divisions).<sup>25</sup> In our case, the infiltration targeted all these sensory territories—including genicular nerves, the anterior cutaneous branches of femoral nerve, and the posterior capsule via the IPACK block. The proximal ACB further covered the saphenous nerve and its infrapatellar branch, completing the sensory block.

In summary, this case supports the feasibility, safety, and potential utility of the PVI technique in tourniquet-free TKA, especially in high-risk populations. It also underscores the value of integrating targeted hemostatic and analgesic strategies within ERAS frameworks. Further prospective studies are warranted to validate these findings, standardize the technique, and evaluate long-term outcomes.

This report is limited by its single-patient design and short-term follow-up. The technique is operator-dependent, and we did not assess objective measures of coagulation or long-term functional outcomes. In addition, systemic effects of dexmedetomidine were not monitored, and the exact spread of the injected solution remains unconfirmed.

## Conclusion

This case highlights the potential of PVI as an effective, tourniquet-free strategy for managing both analgesia and intraoperative hemostasis in TKA. By selectively targeting key sensory nerve territories and combining vasoconstrictive

and analgesic agents, PVI offers a motor-sparing, blood-sparing alternative that aligns with enhanced recovery and opioid-sparing protocols. While these results are encouraging, further studies are needed to validate the reproducibility and long-term safety of this approach across diverse patient populations and surgical settings.

## Abbreviations

ACB, Adductor Canal Block; ASA, American Society of Anesthesiologists; BMI, Body Mass Index; COPD, Chronic Obstructive Pulmonary Disease; DVT, Deep Vein Thrombosis; ERAS, Enhanced Recovery After Surgery; GNB, Genicular Nerve Block; IMGN, Inferior Medial Genicular Nerve; IPACK, Infiltration Between the Popliteal Artery and the Capsule of the Knee; LIA, Local Infiltration Analgesia; LMWH, Low-Molecular-Weight Heparin; NRS, Numerical Rating Scale; PVI, Periarticular Vasoconstrictor Infiltration; SA, Spinal Anesthesia; SLGN, Superior Lateral Genicular Nerve; SMGN, Superior Medial Genicular Nerve; TKA, Total Knee Arthroplasty; US, Ultrasound.

## Ethics Approval

Institutional approval from the Local Ethics Committee (Comitato Etico Territoriale Lazio Area 3) of Isola Tiberina Hospital – Gemelli Isola (Rome, Italy) was not required for the publication of this case report.

## Consent Statement

Written informed consent was obtained from the patient for the publication of this case report and the accompanying images and video material.

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## Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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## Disclosure

The authors report no conflicts of interest in this work.

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