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Advances in knee surgery: periarticular vasoconstrictor infiltration technique

Avances en cirugía de rodilla: técnica de infiltración vasoconstrictora periarticular

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ABSTRACT. Introduction: advancements in knee surgery, notably periarticular vasoconstrictor infiltration (PVI), enhance surgical precision and reduce intraoperative bleeding. PVI involves injecting vasoconstrictive agents around the knee joint pre-surgery to constrict blood vessels, improving visibility, and promoting hemostasis. Our study assesses PVI's impact on intraoperative bleeding during total knee arthroplasty (TKA), aiming to optimize surgical conditions and minimize complications. **Material and methods:** an observational study at Grupo Médico la Salud hospital, Aguascalientes, Mexico, was carried out. Elective TKA patients underwent PVI with slight modification on the technique regarding the volume of total solution injected. The main outcome focused on intraoperative and postoperative blood loss within 24 hours, excluding tourniquet use. Postoperative analgesia was not assessed. **Results:** 30 patients undergoing TKA were included in the study and PVI was performed, blood loss was evaluated alongside clinical characteristics. The majority were women (73.3%) with a mean age of 69 ± 9 years, primarily diagnosed with Gonarthrosis (93.3%). PVI was conducted without tourniquets, with a median perioperative blood loss of 80 ml and postoperative blood loss of 300 mL. Complications were minimal, promptly managed, with satisfactory patient recovery. **Conclusion:** PVI technique is an effective approach in TKA surgery that minimizes blood loss and complications.

RESUMEN. Introducción: los avances en la cirugía de rodilla, en particular la infiltración periarticular vasoconstrictora (PVI), mejoran la precisión quirúrgica y reducen el sangrado intraoperatorio. La PVI implica la inyección de agentes vasoconstrictores alrededor de la articulación de la rodilla antes de la cirugía para contraer los vasos sanguíneos, mejorar la visibilidad y promover la hemostasia. Este estudio evalúa el impacto de la PVI en el sangrado intraoperatorio durante la artroplastia total de rodilla (ATR), con el objetivo de optimizar las condiciones quirúrgicas y minimizar las complicaciones. **Material y métodos:** se llevó a cabo un estudio observacional en el Hospital Grupo Médico la Salud, Aguascalientes, México. Los pacientes con ATR electiva se sometieron a PVI con una ligera modificación en la técnica con respecto al volumen de solución total inyectada. El resultado principal se centró en la pérdida de sangre intraoperatoria y postoperatoria dentro de las 24 horas, excluyendo el uso de torniquete. No se evaluó la analgesia postoperatoria. **Resultados:** se incluyeron 30 pacientes sometidos a ATR en el estudio y se realizó PVI, se evaluó la pérdida de sangre junto con las características clínicas. La mayoría eran mujeres (73.3%) con una edad media de 69 ± 9 años, con diagnóstico de gonartrosis en su mayoría (93.3%). La PVI se realizó sin torniquetes, con una pérdida sanguínea perioperatoria media de 80 mL y una pérdida sanguínea postoperatoria de 300 mL. Las complicaciones fueron mínimas, se manejaron rápidamente y la recuperación de los pacientes fue satisfactoria. **Conclusión:** la técnica PVI es un abordaje eficaz en la cirugía de artroplastia total de rodilla que minimiza la pérdida sanguínea y las complicaciones.



Abbreviations:

PVI = periarticular vasoconstrictor infiltration

SD = standard deviation

TKA = total knee arthroplasty

VTE = venous thromboembolism

INTRODUCTION

Knee surgery, particularly in the realm of orthopedics, has witnessed significant advancements over the past few decades aimed at optimizing patient outcomes and postoperative recovery^(1,2). In 1987, Klein first described tumescent anesthesia⁽³⁾, and in 2010, Lalonde introduced a tumescent local anesthesia for wide awake hand surgery⁽⁴⁾.

Among these advancements, periarticular vasoconstrictor infiltration (PVI) has emerged as a valuable adjunct technique to enhance surgical precision and minimize intraoperative bleeding⁽⁵⁾. This technique involves the local administration of vasoconstrictive agents around the knee joint, effectively reducing blood flow and providing a clearer surgical field for the orthopedic surgeon, it was first proposed in 2022 by Roques Escobar et al. and it has been performed in elective orthopedic surgeries including hip arthroplasty, knee arthroplasty, arthroscopy and arthroplasty shoulder surgery, and lumbar arthrodesis with satisfactory results^(5,6). PVI is an ultrasound-guided technique that should be performed after the primary anesthesia procedure (spinal or general anesthesia, as appropriate) by ultrasound-guided injections at multiple sites using a 20G, 100-mm echogenic needle.

During PVI, different agents such as epinephrine or ropivacaine are injected into the soft tissues surrounding the knee joint prior to surgery⁽⁷⁾. Epinephrine is a potent alpha-adrenergic stimulator with local effects lasting 1-2 hours and peak ischemic action 30 minutes after administration. If absorbed or injected intravascularly, its plasma half-life is short (2-3 minutes) due to rapid enzymatic degradation⁽⁴⁾. These agents work to constrict blood vessels in the area, thereby reducing blood flow and minimizing intraoperative bleeding and also provide pain management. The PVI technique aims to achieve several objectives: by reducing intraoperative bleeding, PVI enhances the surgeon's ability to visualize the surgical field clearly⁽⁵⁾. This improved visibility facilitates more precise surgical maneuvers and enhances overall surgical efficiency. Also, by reducing bleeding, the PVI technique eliminates the need for a tourniquet, thereby avoiding the associated tourniquet-induced pain. Vasoconstrictive agents applied through PVI help to promote hemostasis, or the cessation of bleeding, during the surgical procedure. This reduces the need for excessive cautery or other hemostatic measures, which can potentially damage surrounding tissues. In addition to its hemostatic effects, PVI can also provide local

anesthesia to the surgical site when using with local anesthetic, contributing to postoperative pain management and reducing the need for systemic analgesics⁽⁸⁾. The technique involves the injection of epinephrine (1:100,000), administering 20 mL at each of five points: periarterial superolateral genicular, periarterial superomedial genicular, periarterial inferolateral genicular, periarterial inferomedial genicular, articular and along the dissection site.

The assessment of intraoperative bleeding during total knee arthroplasty (TKA) serves as a critical determinant of surgical efficiency and perioperative outcomes. Excessive bleeding not only complicates the surgical procedure but also poses challenges in achieving optimal implant alignment and soft tissue balance, which are crucial factors for long-term implant survival and functional outcomes⁽⁹⁻¹¹⁾.

While PVI has demonstrated efficacy in improving surgical visualization, decreased bleeding, and potentially reducing postoperative pain and swelling^(6,7), variations in its application and outcomes have prompted further exploration and refinement. Our study seeks to comprehensively evaluate bleeding patterns during TKA, with a particular focus on the impact of PVI on intraoperative hemostasis. By meticulously quantifying intraoperative blood loss and postoperative complications, we aim to elucidate the efficacy of this adjunct technique in mitigating bleeding and optimizing surgical conditions. The objective of this study was to evaluate the efficacy of periarticular vasoconstrictor infiltration in reducing intraoperative bleeding during total knee arthroplasty and to assess its impact on perioperative outcomes.

MATERIAL AND METHODS

We conducted an observational study with patients undergoing elective TKA surgery in Grupo Médico la Salud in Aguascalientes, Mexico. Written informed consent was provided by all patients undergoing this technique and the study was approved by the hospital ethics committee.

The inclusion criteria were adult patients 18 years or older scheduled for elective primary TKA and who provided written informed consent. The exclusion criteria included patients with any known allergy to anesthetics, history of coagulopathy or active local or systemic infection or refusal to participate in the study. Patients who did not meet inclusion criteria or who withdrew consent were considered non-inclusion cases.

The PVI technique was performed as described by Roqués V et al.⁽⁷⁾ with slight modifications adapted to our surgical protocol. Two portable ultrasound machines (Butterfly iQ3 and Sonosite M-Turbo) were used. A 20G, 100 mm echogenic needle was employed for injections. Regarding the infiltrated solution, 100 mL of 0.9% saline solution mixed with 1mg of epinephrine (1/100,000).

After establishing anesthesia, an average of 96.8 ± 7.48 mL of solution was infiltrated into five points: superolateral, superomedial, inferolateral, inferomedial, and the injection site (*Figure 1*).

The modification of the volume and distribution of infiltration was based on local pharmacological safety considerations and adaptations to TKA surgical anatomy.

The primary outcome assessed was the intraoperative and postoperative blood loss (within the first 24 hours), the secondary outcomes considered were postoperative complications including hematoma, infection, thromboembolism, and delayed wound healing. The intraoperative blood loss was estimated by measuring suctioned fluid (subtracting irrigation volume) and by quantifying the blood absorbed in surgical sponges, while postoperative blood loss was obtained through collection with the Drenovac drainage system.

Patients underwent surgery without the use of tourniquet since it has shown to provide higher risk of postoperative pain and venous thromboembolism (VTE). Postoperative analgesia was not evaluated in this study.

Descriptive statistics were used to summarize demographic and clinical data, categorical variables were described with frequencies and percentages; on the other hand, continuous

variables were expressed as mean $\pm$ standard deviation (SD). No inferential analysis was carried out.

RESULTS

We evaluated 30 patients undergoing elective TKA surgery. The proportion of women was higher in the study group with 22 patients (73.3%), and the mean age was 69 ± 9 years. The main diagnosis of the patients and the reason for surgery was Gonarthrosis in 93.3% of cases. Among the clinical characteristics of the patients, the majority had a prior diagnosis of hypertension (80%) and were overweight. All clinical characteristics are detailed in *Table 1*.

The total surgery time was 83 ± 9 minutes, with a minimum time of 75 minutes and a maximum of 108 minutes. Perioperative bleeding was measured, with a median of 80 mL and an interquartile range of 50-95 mL. The minimum recorded loss was 30 mL, and the maximum loss was 500 mL. The surgical site required five stitches. Postoperative blood loss was also evaluated 12-24 hours after surgery, with a median of 300 mL and an interquartile range of 100-400 mL (*Table 2*).

We evaluated perioperative complications. In 93.3% of cases ($n = 28$), there were no complications; one patient

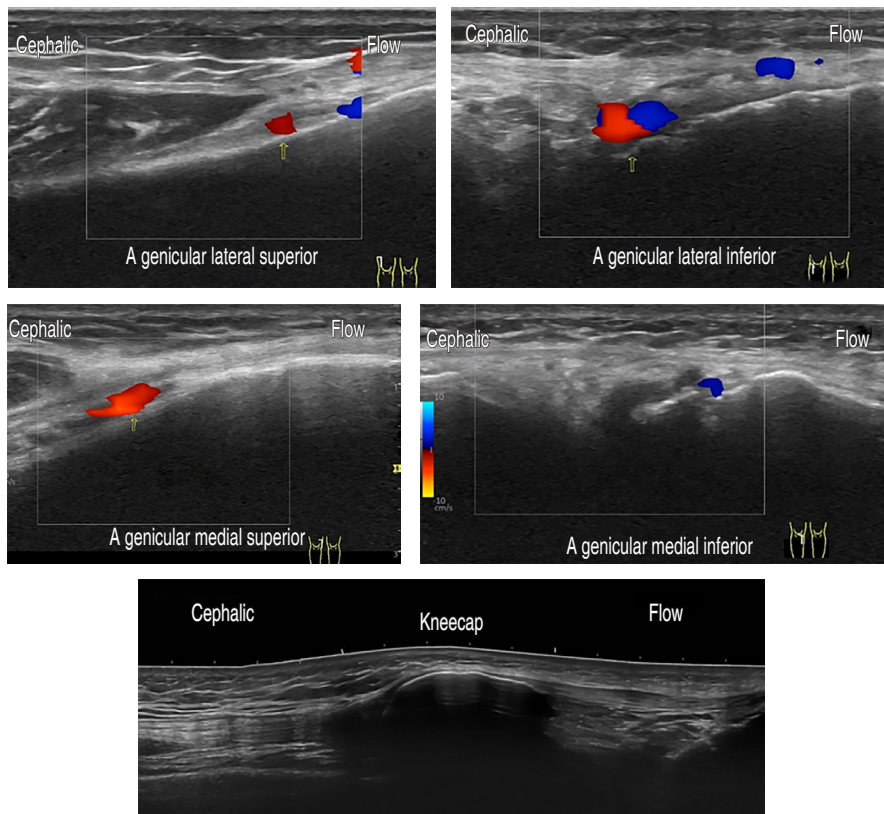


Figure 1: Infiltration points.

Table 1: Clinical characteristics of the patients.

	n (%)
Gender	
Male	8 (26.7)
Female	22 (73.3)
Comorbidities	
Hypertension	24 (80.0)
Cardiopathy	8 (26.7)
Diabetes mellitus	9 (30.0)
Thyroid diseases	2 (6.7)
Others	4 (13.3)
Body measures	
Weigh, kg	77.37 ± 11.98
Height, m	1.63 ± 0.07
Body mass index, kg/m ²	28.98 ± 4.49
Body mass index	
Normal	5 (16.7)
Overweight	14 (46.7)
Obesity	
Grade I	9 (30.0)
Grade II	1 (3.3)
Grade III	1 (3.3)
Diagnosis	
Gonarthrosis	28 (93.3)
Prosthesis loosening	1 (3.3)
Pseudarthrosis	1 (3.3)

experienced hypertension, and another patient had tachycardia, however these two complications were more closely associated with the patient's anxiety and nervousness. Regarding late postoperative complications, 83.3% had no issues. In 3 cases, delayed wound healing was observed, one case presented infection of soft tissue, and one patient required red blood cell transfusion. All complications were promptly addressed and were associated with preexistent comorbidities and not to the PVI, the patients achieved satisfactory recovery (*Table 3*).

DISCUSSION

The present observational study aimed to evaluate the perioperative and postoperative outcomes of patients undergoing elective total knee arthroplasty (TKA) using a novel periarticular infiltration technique.

Our results showed that most patients undergoing elective TKA were female, consistent with reports indicating a higher prevalence of TKA in women⁽¹⁰⁻¹³⁾. Gonarthrosis was the primary diagnosis in 93.3% of cases, reaffirming its role as the leading indication for TKA. This procedure remains an effective treatment for advanced gonarthrosis, especially in patients over 65 years old, with long-term prosthetic survival rates exceeding 95% in some studies⁽¹²⁾.

Hypertension was the most common comorbidity among patients (80%), followed by cardiopathy (26.7%) and diabetes mellitus (30.0%). The rising prevalence of hypertension presents a significant concern in the context

of surgical procedures such as TKA. As hypertension becomes increasingly common in the population, surgeons are encountering a higher proportion of patients with this comorbidity undergoing TKA. Hypertension, with its associated cardiovascular risks, poses challenges during the perioperative period, including the management of blood pressure control and the prevention of perioperative complications such as bleeding and cardiovascular events. Also, the presence of hypertension and obesity correlates with increased blood loss and need for transfusion in comparison to non-obese patients with normal blood pressure undergoing primary elective TKA. Therefore, it is crucial for healthcare providers to carefully assess and optimize the management of hypertension in patients undergoing TKA to ensure optimal surgical outcomes and minimize perioperative risks⁽¹³⁻¹⁵⁾.

Significant blood loss remains a prevalent surgical concern in significant orthopedic procedures, carrying acknowledged costs and potential complications. In total hip or knee replacement surgeries, estimated blood loss typically ranges from 726 to 1,768 mL and it depends on the technique used, surgery time and patients' characteristics like comorbidities⁽¹⁶⁾. In our series, intraoperative bleeding had a median of 80mL, supporting the hemostatic effect of PVI.

The primary benefit of PVI lies in its ability to significantly reduce overall surgical bleeding to less than 100 mL⁽¹⁷⁾. In addition, evidence suggests that the use of epinephrine in periarticular blocks may decrease postoperative bleeding without elevating the risk of deep venous thrombosis^(18,19).

Something important to address in this study was the modification of the original technique. We reduced the total infiltration volume and adjusted the distribution to the surgical field of TKA. The modification was based on anatomical considerations and pharmacological safety and with the objective to maximize hemostasis.

Regarding the limitations of this study, we did not assess hemoglobin variation through hemograms at a pre and postoperative status. This limits the objectivity of our bleeding assessment, and this should be considered in future studies.

Notably, perioperative complications were minimal, with only two cases of hypertension and tachycardia observed, although we attributed them to patient anxiety, systemic absorption of epinephrine cannot be entirely excluded. One patient required a blood transfusion; this may suggest that PVI may not eliminate the need for transfusion in all cases, especially in cases with multiple comorbidities.

Table 2: Blood loss during and after surgery.

	Median	Quartile 25	Quartile 75	Min.-Max.
Perioperative, mL	80	50	90	30-500
Postoperative, mL	300	100	400	400-700

Table 3: Perioperative and postoperative complications.

	n (%)
Perioperative	
None	28 (93.3)
Hypertension	1 (3.3)
Tachycardia	1 (3.3)
Postoperative	
None	25 (83.3)
Soft tissue infection	1 (3.3)
Delayed wound healing	3 (10.0)
Red blood cell transfusion	1 (3.3)

Postoperative complications occurred in a small proportion of patients, with delayed wound healing being the most common issue and related to preexistent comorbidities.

The postoperative bleeding was greater than intraoperative bleeding; this suggests that the beneficial effect the vasoconstrictors may be higher during the intraoperative period and early postoperative hours and less sustained afterwards. For this matter, it would be important to consider longer-acting vasoconstrictors to extend the hemostatic benefit.

Late complications observed in a minority of patients, including delayed wound healing may be explained by comorbid conditions such as obesity and diabetes. But also, it is important to mention that reduced blood supply induced by the vasoconstrictors could theoretically impair wound healing process.

CONCLUSIONS

Our study demonstrates that PVI technique used in elective TKA surgery appears to reduce intraoperative bleeding and was associated with a low rate of complications. Despite minor complications such as delayed wound healing and soft tissue infection, most patients recovered satisfactorily. These findings suggest that the PVI technique may be a useful adjunct to improve surgical field visibility and hemostasis, but the benefits seem to be most pronounced in the intraoperative stage and immediate postoperative period. However, further research with larger sample sizes and comparative studies with standard techniques is warranted to validate our findings and determine the long-term efficacy of PVI technique in TKA surgery.

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