Safety and feasibility of ambulatory transperineal MRI–ultrasound fusion prostate biopsy under general anesthesia

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Abstract

Background: Ambulatory procedures performed in non-operating room settings require anesthetic strategies that ensure patient safety, procedural efficiency, and rapid recovery. We evaluated the safety and feasibility of a standardized outpatient pathway based on target-controlled general anesthesia with spontaneous ventilation for transperineal magnetic resonance imaging–ultrasound (MRI–US) fusion-targeted prostate biopsy. As a secondary exploratory analysis, we assessed the association of adjunctive local anesthesia with anesthetic requirements and patient outcomes.

Methods: This retrospective single-center cohort study included 381 consecutive patients undergoing ambulatory transperineal MRI–US fusion-targeted prostate biopsy between 2019 and 2023. General anesthesia was administered using target-controlled propofol and remifentanil infusions while maintaining spontaneous ventilation. Perioperative complications, procedure-room time, anesthetic drug requirements, postoperative pain, and patient satisfaction were analyzed. Multivariable regression models evaluated factors associated with anesthetic requirements and postoperative pain.

Results: All procedures were completed successfully in the ambulatory setting. The median procedure-room time was 30 minutes (IQR 25–34.5), and perioperative complications were uncommon, with only one episode of transient respiratory depression requiring manual ventilation. Patients receiving adjunctive local anesthesia (n=152) required significantly lower propofol and remifentanil doses and had shorter procedure-room times than those managed without local anesthesia (all $p < 0.05$). Postoperative pain was minimal, with 95.7% of patients reporting no or mild pain within 24 hours. Patient satisfaction was high.

Conclusions: A standardized ambulatory pathway using target-controlled general anesthesia with spontaneous ventilation is a safe and feasible anesthetic strategy for transperineal MRI–US fusion-targeted prostate biopsy. Adjunctive local anesthesia reduces anesthetic requirements while maintaining excellent patient comfort and procedural outcomes.

Keywords: Ambulatory anesthesia; Non-operating room anesthesia; Target-controlled infusion; Transperineal prostate biopsy; Perioperative care.

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Introduction

The increasing adoption of ambulatory care pathways has led to a growing demand for anesthetic strategies that ensure procedural safety, patient comfort, rapid recovery, and efficient use of healthcare resources [1,2]. These requirements are particularly relevant in non-operating room anesthesia (NORA) environments, where procedures traditionally performed in the operating room are increasingly being transferred to dedicated outpatient units [3,4]. In this setting, anesthetic techniques must provide adequate procedural conditions while minimizing perioperative morbidity and facilitating same-day discharge [3-5].

Transperineal magnetic resonance imaging–ultrasound (MRI–US) fusion-targeted prostate biopsy has become an established diagnostic procedure for patients with suspected prostate cancer [6]. Compared with the transrectal approach, the transperineal route is associated with fewer infectious complications and improved access to the anterior prostate, leading the current European Association of Urology guidelines to recommend its use whenever feasible [7-10]. In addition, MRI–US fusion systems improve lesion targeting and diagnostic accuracy by enabling precise sampling of suspicious areas identified on multiparametric MRI [11,12].

Despite these advances, anesthetic management remains an important challenge [13]. Accurate MRI–US fusion targeting requires patient immobility, while the transperineal approach may cause discomfort due to needle passage through multiple tissue planes [14]. Local anesthesia has been successfully implemented in many centers; however, pain control may be variable and patient discomfort during infiltration, probe manipulation, and biopsy sampling remains a concern [14,15]. Conversely, conventional general anesthesia with airway instrumentation may increase resource utilization, prolong recovery, and reduce the efficiency of ambulatory pathways.

The availability of short-acting intravenous agents administered through target-controlled infusion (TCI) systems has facilitated the development of non-intubated anesthetic techniques based on spontaneous ventilation [16]. This approach may provide adequate procedural conditions while preserving respiratory function, allowing rapid recovery and facilitating outpatient management [17,18]. However, data regarding the safety, feasibility, and anesthetic requirements of general anesthesia with spontaneous ventilation for ambulatory MRI–US fusion prostate biopsy remain limited.

The primary objective of this study was to evaluate the safety and feasibility of a standardized outpatient anesthesia pathway

based on target-controlled propofol and remifentanil infusions with spontaneous ventilation for transperineal MRI–US fusion-targeted prostate biopsy. A secondary exploratory objective was to investigate whether the use of adjunctive local anesthesia was associated with differences in anesthetic requirements, procedure-room time, and patient-reported outcomes.

Methods

Study design and population

This retrospective single-center cohort study evaluated a standardized ambulatory anesthesia pathway for transperineal MRI–US fusion-targeted prostate biopsy performed under general anesthesia with spontaneous ventilation. Consecutive adult patients undergoing the procedure between November 2019 and December 2023 were included.

The study was approved by the Ethics Committee of Hospital Clinic Barcelona (HCB/2024/0012) and was conducted in accordance with the Declaration of Helsinki. The requirement for informed consent was waived due to the retrospective nature of the study.

Setting and ambulatory pathway

All procedures were performed in a dedicated outpatient non-operating room environment staffed by an anesthesiologist, specialized nursing personnel, and an experienced urologist (Figure 1).

Patients underwent a pre-procedural nursing assessment and received standardized antibiotic prophylaxis with fosfomycin (3 g) the day before and the day after biopsy. Following completion of the procedure, patients were transferred to the post-anesthesia care unit (PACU), where they remained under observation for a minimum of one hour before discharge according to institutional criteria.

A structured telephone follow-up was conducted 24 hours after discharge to assess postoperative pain, analgesic consumption, complications, and overall patient satisfaction.



Figure 1. Room setup for ambulatory transperineal MRI–US fusion-targeted biopsy at our institution.

Anesthetic management

Standard monitoring included electrocardiography, pulse oximetry, and non-invasive blood pressure monitoring. Supplemental oxygen was administered via nasal cannula.

Patients were placed in the lithotomy position before induction. Premedication with intravenous midazolam was administered at the discretion of the attending anesthesiologist.

General anesthesia was induced and maintained using target-controlled infusions (TCI) of propofol and remifentanil delivered through an Orchestra Base Primea® system (Fresenius Kabi, Germany). Effect-site concentrations were calculated using the Schnider pharmacokinetic model for propofol [19] and the Minto model for remifentanil [20]. Initial target concentrations were set at 1 μg/mL for propofol and 1 ng/mL for remifentanil and subsequently adjusted according to procedural requirements while maintaining spontaneous ventilation throughout the intervention. Airway instrumentation was not routinely performed.

Beginning in June 2022, adjunctive local anesthesia was incorporated into the institutional protocol. Local anesthesia consisted of subcutaneous infiltration of 10 mL of 2% lidocaine (200 mg) through a single midline perineal puncture approximately 1.5 cm from the anal verge, allowing bilateral diffusion. Ultrasound image acquisition was initiated 2–5 minutes after infiltration. Because this protocol was implemented during the study period, comparisons between patients receiving and not receiving local anesthesia represent a historical, non-randomized comparison. Consequently, the use of local anesthesia was determined by the institutional protocol in place at the time of the procedure rather than by patient characteristics.

Biopsy procedure

Biopsies were performed using an elastic MRI–US fusion platform (Koelis Trinity®, Meylan, France) with a transperineal mini-grid system.

Targeted biopsies of MRI-visible lesions were combined with systematic sampling according to institutional practice. Procedures were performed by experienced urologists specialized in transperineal MRI–US fusion biopsy.

Procedure-room time was defined as the interval between anesthetic induction and completion of biopsy sampling.

Data collection and outcomes

Demographic, clinical, anesthetic, and procedural variables were extracted from electronic medical records. Collected variables included age, body mass index, American Society of Anesthesiologists (ASA) physical status, comorbidities, prostate-specific antigen (PSA) level, prostate volume, Prostate Imaging Reporting and Data System (PI-RADS) score, number of MRI-detected lesions, biopsy results, anesthetic drug doses, effect-site concentrations, procedure-room time, perioperative complications, postoperative pain scores, analgesic consumption, and patient satisfaction.

The primary outcome was procedural safety, defined as the composite incidence of anesthesia-related and procedure-related complications occurring during the procedure or within 24 hours after discharge. Anesthesia-related complications included respiratory depression requiring airway maneuvers or airway adjuncts, bradycardia (<50 beats/min), and hypotension (mean arterial pressure <60 mmHg). Procedure-related complications included urinary tract infection, hematuria, rectal bleeding, acute urinary retention, and perineal hematoma.

Secondary outcomes included procedure-room time, propofol and remifentanil requirements, postoperative pain measured using a numeric rating scale (NRS) during the first 24 hours, postoperative analgesic consumption, and patient satisfaction, assessed as willingness to undergo the procedure again under the same conditions. Postoperative pain, analgesic consumption, and patient satisfaction were assessed during a standardized telephone follow-up conducted 24 hours after the procedure. Analyses of these patient-reported outcomes were performed in patients who completed follow-up. Comparisons according to adjunctive local anesthesia were considered exploratory because local anesthesia was introduced during the study period and patients were not randomized.

Statistical analysis

Continuous variables are reported as median (interquartile range [IQR]) or mean (standard deviation), according to distribution. Categorical variables are presented as frequencies and percentages.

Group comparisons were performed using the Mann–Whitney U test or Student's t-test for continuous variables, as appropriate, and the chi-square test or Fisher's exact test for categorical variables.

Multivariable linear regression models were used to identify independent predictors of propofol and remifentanil requirements. Covariates were selected a priori based on clinical relevance and availability as preprocedural patient or disease characteristics potentially associated with anesthetic requirements. The models were adjusted for age, body mass index, prostate volume, and premedication. Procedure-room time was excluded from the models because it may be influenced by the exposure and therefore represent a post-exposure variable. Multivariable logistic regression was performed to identify factors associated with postoperative pain, which was dichotomized as no pain versus any pain (NRS ≥1).

Because adjunctive local anesthesia was introduced as a protocol change during the study period, comparisons between patients receiving and not receiving local anesthesia were considered exploratory and hypothesis-generating rather than confirmatory. Multivariable regression models were therefore used to adjust for measured baseline differences; however, residual confounding related to temporal changes in clinical practice cannot be excluded.

Statistical significance was defined as $p < 0.05$. Analyses were performed using SPSS version 30 (IBM Corp., Armonk, NY, USA).

Missing data were evaluated before analysis. Cases with missing values in variables required for multivariable models were excluded using complete-case analysis.

Results

Study population

A total of 381 consecutive patients underwent ambulatory transperineal MRI–US fusion-targeted prostate biopsy under general anesthesia with spontaneous ventilation during the study period. Adjunctive local anesthesia (LA) was administered to 152 patients (39.9%), whereas 229 patients (60.1%) underwent the procedure without LA.

Baseline demographic and clinical characteristics are summarized in Table I. The median age of the cohort was 68 years (IQR 62–74), and most patients were classified as ASA II. Body mass index, prostate volume, number of MRI-detected lesions, and PI-RADS distribution were comparable between groups. Median PSA levels were higher in the non-LA group, while cardiovascular comorbidity was more frequent in patients receiving LA. These variables were included as covariates in the multivariable analyses.

Ambulatory pathway performance

The ambulatory pathway was successfully completed in all patients without the need for hospital admission or conversion to conventional operating room anesthesia.

Median procedure-room time was 30 minutes (IQR 25–34.5) and was significantly shorter in patients receiving adjunctive local anesthesia ($p = 0.003$).

The incidence of perioperative complications was low. One patient (0.26%; 95% CI: 0.01–1.47%) experienced transient respiratory depression requiring brief manual ventilation, and two patients (0.52%; 95% CI: 0.06–1.90%) developed transient hemodynamic instability, both of which resolved with conservative management. Procedure-related complications within the first 24 hours included urinary tract infection (1.3%; 95% CI: 0.43–3.04%), hematuria (1.05%; 95% CI: 0.29–2.67%), acute urinary retention (0.52%; 95% CI: 0.06–1.90%), rectal bleeding (0.26%; 95% CI: 0.01–1.45%), and perineal hematoma (0.26%; 95% CI: 0.01–1.45%).

Overall, the findings support the feasibility of performing transperineal MRI–US fusion biopsy under general anesthesia with spontaneous ventilation in a dedicated outpatient non-operating room setting. Following the primary analysis of procedural safety and feasibility, exploratory analyses were performed to evaluate factors associated with anesthetic requirements and patient-reported outcomes.

Anesthetic performance

Anesthetic management outcomes are summarized in Table II. Patients receiving adjunctive LA required significantly lower target effect-site concentrations and total doses of both propofol and remifentanil than patients managed without LA

Table I. Patient and prostate characteristics.

	LA (n=152)	Non-LA (n=229)	All (n=381)	p
Age (yr): median (IQR)	68 (61-74)	68 (63-74)	68 (62-74)	0.89[a]
ASA: n (%)	1: 10 (6.62%) 2: 107 (70.86%) 3: 34 (22.52%)	1: 21 (9.21%) 2: 173 (75.88%) 3: 34 (14.91%)	1: 31 (8.18%) 2: 280 (73.88%) 3: 68 (17.94%)	0.14[b]
BMI (kg/m2): median (IQR)	26.57 (24.22-29.32)	26.67 (24.62-28.71)	26.66 (24.49-29.05)	0.79[a]
Prostate volume (cc): median (IQR)	57 (39.50-79.50)	57 (42-79)	57 (40-79)	0.82[b]
Number of lesions: n (%)	1: 122 (80.26%) 2: 30 (19.74%)	1: 182 (79.48%) 2: 47 (20.52%)	1: 304 (79.79%) 2: 77 (20.21%)	0.85[b]
PI-RADS 3, 4, 5: n (%)	3: 22 (14.47%) 4: 113 (74.34%) 5: 17 (11.18%)	3: 45 (19.65%) 4: 146 (63.76%) 5: 38 (16.59%)	3: 67 (17.59%) 4: 259 (67.98%) 5: 55 (14.44%)	0.09[b]
PSA (ng/mL): median (IQR)	5.60 (4.40-7.10)	6.50 (5.00-9.70)	6.10 (4.60-8.50)	**<0.001**[a]
Comorbidity: n (%) **DM** **HTN** **CV** **Respiratory** **None**	 18 (12.08%) 73 (48.99%) 36 (24.16%) 19 (12.75%) 27 (18.12%)	 34 (14.85%) 113 (49.34%) 32 (13.97%) 19 (8.30%) 48 (20.96%)	 52 (13.76%) 186 (49.21%) 70 (18.52%) 41 (10.89%) 75 (19.84%)	 0.44[b] 0.94[b] 0.01[b] 0.16[b] 0.50[b]

LA: local anesthesia. IQR: (interquartile range. ASA: American Society of Anesthesiologists. BMI: body mass index. PI-RADS: Prostate Imaging Reporting and Data System. PSA: prostate-specific antigen. DM: diabetes mellitus. HTN: hypertension. CV: cardiovascular. Bold values indicate statistically significant results (p < 0.05). [a]*Wilcoxon rank-sum test* [b]Chi-square test of independence.

Table II. Effect-site concentrations, total drug doses, and premedication.

	LA (n = 152)	Non-LA (n = 229)	All (n = 381)	p
Premedication (midazolam): n (%)	2 (1.34%)	13 (5.70%)	15 (3.98%)	0.03[b]
Propofol Ce (µg/mL): median (IQR)	2 (1.5-2.5)	2.50 (1.50-3)	2.2 (1.50-2.80)	**<0.001**[a]
Propofol total dose (mg): median (IQR)	167.50 (140.50-200)	231 (191-281)	200 (161-250)	**<0.001**[a]
Remifentanil Ce (ng/mL): median (IQR)	1.50 (1.40-2)	2 (1.60-2)	1.80 (1.50-2)	**<0.001**[a]
Remifentanil total dose (µg): median (IQR)	108 (82-125)	133 (105-160)	121 (99-148)	**<0.001**[a]

LA: local anesthesia. *IQR: interquartile range. Ce: effect-site concentration.* [a]*Wilcoxon rank-sum test* [b]*Chi-square test of independence.*

(all $p < 0.001$). Premedication with midazolam was infrequently administered overall but was more common in the non-LA group.

In multivariable linear regression analyses, adjunctive LA remained independently associated with reduced propofol (B = −69.61 mg; 95% CI, −86.00 to −53.22; $p < 0.001$) and remifentanil requirements (B = −27.62 µg; 95% CI, −38.11 to −17.12; $p < 0.001$), after adjustment for age, body mass index, prostate volume, and premedication. Higher body mass index was independently associated with increased anesthetic drug consumption, whereas increasing age predicted lower anesthetic requirements.

Patient-reported outcomes

Telephone follow-up at 24 hours was successfully completed in 371 of the 381 patients (97.4%). Ten patients (2.6%) could not be contacted despite repeated attempts. Among patients who completed follow-up, postoperative pain was minimal: 174 (46.9%) reported no pain, 184 (49.6%) reported mild pain (NRS 1–3), and 13 (3.5%) reported moderate pain (NRS 4–6). No patient reported severe pain.

In multivariable logistic regression analyses, postoperative pain was not significantly associated with the use of adjunctive local anesthesia (OR = 1.57; 95% CI, 0.78–3.14; p = 0.20), remifentanil dose (OR = 1.00; 95% CI, 0.99–1.01; p = 0.89), prostate volume (OR = 0.99; 95% CI, 0.99–1.01; p = 0.80), or intraoperative analgesia (OR = 1.02; 95% CI, 0.97–1.07; p = 0.48). Younger age was the only independent predictor of higher postoperative pain scores (OR = 2.02; 95% CI, 1.44–4.14; p = 0.01).

Patient satisfaction was consistently high. Among the 371 patients who completed follow-up, 368 (99.2%) reported that they would be willing to undergo the same anesthetic technique again if another prostate biopsy were required, whereas only 3 (0.8%) stated that they would not. Owing to the very small number of patients unwilling to repeat the procedure, no comparative analysis of this outcome was performed.

Diagnostic findings

Prostate adenocarcinoma was diagnosed in 268 patients (70.3%), with most cancers detected in lesions classified as PI-RADS 4 or 5 on preoperative multiparametric MRI.

Discussion

This study shows that a standardized ambulatory pathway based on target-controlled propofol and remifentanil infusions with spontaneous ventilation provides a safe, feasible, and well-tolerated anesthetic strategy for transperineal MRI–US fusion-targeted prostate biopsy performed in a dedicated non-operating room setting. In this large single-center cohort, perioperative complications were uncommon, postoperative pain was minimal, and patient satisfaction was consistently high. The exploratory comparison between patients treated with and without adjunctive local anesthesia suggests that local anesthesia was associated with lower anesthetic requirements and shorter procedure-room time, although this observation should be interpreted cautiously given the non-randomized historical design.

The expansion of ambulatory surgery and NORA has increased interest in anesthetic techniques capable of providing optimal procedural conditions while facilitating rapid recovery and efficient resource utilization [21]. Transperineal MRI–US fusion biopsy represents a challenging outpatient procedure because accurate lesion targeting requires complete patient immobility, while the transperineal approach may generate discomfort during needle insertion and sampling [14,15]. Consequently, the anesthetic strategy should not only ensure patient comfort but also optimize procedural conditions and support an efficient ambulatory workflow [22].

Although local anesthesia has been increasingly adopted for transperineal prostate biopsy, patient tolerance remains variable [14,23]. Previous studies have reported that local anesthetic infiltration is frequently perceived as the most painful component of the procedure, and a proportion of patients continue to experience moderate or severe discomfort during probe manipulation and biopsy sampling [15]. Furthermore, patient movement during the procedure may compromise targeting accuracy and occasionally prolong procedural time. Our findings suggest that general anesthesia with spontaneous ventilation provides excellent procedural conditions while avoiding the airway instrumentation, neuromuscular blockade, and prolonged recovery commonly associated with conventional general anesthesia.

An important finding of the present study is the favorable safety profile of this anesthetic approach. Respiratory and hemodynamic complications were rare, with only one patient requiring brief manual ventilation and no patient requiring conversion to controlled ventilation or advanced airway management. These results support the feasibility of maintaining spontaneous ventilation during relatively short interventional procedures performed outside the conventional operating room. The use of target-controlled infusion systems likely contributed to this favorable profile by allowing continuous titration of anesthetic depth according to procedural requirements while avoiding excessive drug administration [24,25].

Target-controlled infusion has become an established technique for ambulatory anesthesia because it provides predictable pharmacokinetics, facilitates rapid adjustments in anesthetic depth, and promotes prompt postoperative recovery [26-28]. In our cohort, propofol and remifentanil administered using validated pharmacokinetic models provided stable procedural conditions with very low rates of respiratory compromise. This is particularly relevant in older patients undergoing diagnostic procedures, in whom minimizing physiological disturbance while maintaining procedural quality is an important perioperative objective.

One of the most clinically relevant findings was the independent association between adjunctive local anesthesia and reduced propofol and remifentanil requirements. Although postoperative pain scores did not differ between groups, patients receiving local anesthesia consistently required lower anesthetic doses after adjustment for age, body mass index, prostate volume, and premedication. This suggests that local anesthesia primarily functions as an anesthetic-sparing strategy rather than as a means of improving postoperative analgesia when an adequate level of general anesthesia is already provided. Reducing anesthetic drug exposure may contribute to faster recovery and fewer drug-related adverse effects, particularly in older patients and those with multiple comorbidities. However, these findings should be interpreted cautiously. Adjunctive local anesthesia was introduced as part of an institutional protocol change during the study period rather than through random allocation. Consequently, differences between groups may also reflect temporal improvements in operator experience, refinements in procedural workflow, or other unmeasured changes in clinical practice. Although multivariable analyses adjusted for measured baseline characteristics, residual confounding cannot be excluded.

Procedure-room time is another important determinant of ambulatory pathway performance. We observed a median procedure-room time of 30 minutes, which compares favorably with previous reports of transperineal MRI-guided biopsy [29]. Adjunctive local anesthesia was associated with shorter procedure-room times; however, the present study did not evaluate recovery time, discharge readiness, resource utilization, or healthcare costs. Therefore, no conclusions can be drawn regarding the overall efficiency or economic impact of this ambulatory pathway. Future prospective studies incorporating these outcomes are required to determine whether the observed reduction in anesthetic requirements translates into improvements in perioperative workflow or resource utilization.

Patient-reported outcomes are increasingly recognized as key quality indicators in perioperative medicine [30]. Nearly all patients reported no or only mild postoperative pain, and almost every participant indicated willingness to undergo the same anesthetic technique again if required. These findings emphasize that successful ambulatory pathways should be evaluated not only by complication rates but also by patient experience, comfort, and acceptability. Such outcomes are particularly relevant in prostate cancer diagnostics, where repeated biopsies may be required during active surveillance [31,32].

This study has several limitations. Its retrospective, single-center design limits causal inference and external validity. The introduction of adjunctive local anesthesia during the study period resulted in a historical comparison rather than a randomized allocation, introducing the possibility of temporal bias and confounding related to increasing operator experience. Although multivariable analyses were performed to adjust for important baseline differences, residual confounding cannot be excluded. In addition, formal recovery times, discharge readiness scores, patient-reported recovery measures, and economic outcomes were not available. These endpoints would provide valuable information regarding the overall efficiency and cost-effectiveness of ambulatory anesthetic pathways and should be addressed in future prospective studies.

Despite these limitations, this study represents one of the largest reported series evaluating target-controlled general anesthesia with spontaneous ventilation for ambulatory transperineal MRI–US fusion biopsy. The standardized anesthetic protocol, homogeneous perioperative pathway, and comprehensive assessment of anesthetic, procedural, and patient-reported outcomes provide clinically relevant evidence supporting this approach. Prospective multicenter studies comparing general anesthesia with spontaneous ventilation and contemporary local anesthesia protocols are warranted to determine the optimal anesthetic strategy for transperineal prostate biopsy performed in outpatient settings.

Conclusions

Ambulatory transperineal MRI–US fusion-targeted prostate biopsy performed under target-controlled general anesthesia with spontaneous ventilation is a safe and feasible approach, providing low complication rates, excellent patient tolerance, and high satisfaction. Adjunctive local anesthesia was associated with lower anesthetic requirements and shorter procedure-room time without affecting postoperative pain. Prospective studies are warranted to confirm these findings and evaluate their impact on recovery and perioperative efficiency.

Author contributions

IB, OP, BT, MM: Conceptualization, methodology, and writing – original draft. MC, JB, IA, RG, CD: Data collection and analysis, and methodology. BT, MM: Supervision and critical revision of the manuscript.

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Ethics approval and consent to participate

The study was approved by the institutional Ethics Committee of Hospital Clinic Barcelona (reference HCB/2024/0012). Informed consent was waived due to the retrospective nature of the study. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki and its subsequent amendments.

Disclosures / conflicts of interest statement

There are no financial relationships or conflicts of interest to disclose.

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