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AI-assisted versus conventional ultrasound-guided PECS II block: A randomized study in mastectomy patients

Mastektomi hastalarında AI destekli ile konvansiyonel ultrason eşliğinde PECS II blokun karşılaştırılması: Randomize bir çalışma

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ABSTRACT

Background: This study aims to compare the analgesic efficacy and procedural efficiency of pectoral (PECS II) blocks performed using artificial intelligence (AI)-integrated ultrasonography (USG) versus conventional USG in patients undergoing modified radical mastectomy (MRM).

Patients and Methods: Between November 2021 and March 2023, a total of 70 female patients scheduled for unilateral MRM under general anesthesia were included in this randomized study. The patients were randomly allocated into two groups: USG group (n = 35) and AI-USG group (n = 35). A fourth-year anesthesiology resident performed the PECS II blocks under the supervision of a senior anesthesiologist. The primary outcome was the postoperative pain score as assessed by Visual Analog Scale (VAS) at 12 hours. Secondary outcomes included pain scores at other postoperative time points, total opioid consumption, time first to rescue analgesia request within 24 hours, and the resident's skill development at the end of the study.

Results: The mean age was 55.3±11.4 (range, 35 to 75) years. Intraoperative remifentanil consumption was higher in USG group than in AI-USG group; however, the difference was not statistically significant ($p > 0.05$). The durations of anesthesia and surgery were shorter in AI-USG group ($p = 0.005$ and $p = 0.008$, respectively). A comparison of local anesthetic injection times between the first 35 and the last 35 patients revealed a statistically significant decrease in the USG group (4.0 min *vs.* 3.0 min, $p = 0.014$). The VAS pain scores in the post-anesthesia care unit were initially higher in the AI-USG group ($p = 0.05$); however, at 12 and 24 postoperative hours, VAS scores were significantly lower than those in the USG group ($p = 0.005$ and $p < 0.001$, respectively). There was no significant difference in total tramadol consumption via PCA during the first 24 hours postoperatively ($p > 0.05$). Surgeon satisfaction scores were lower in the AI-USG group ($p = 0.037$).

Conclusion: Our study results suggest that AI-enhanced USG guidance is associated with improved analgesic outcomes and may offer clinical and educational advantages in the performance of PECS II blocks, particularly for residents in training. The integration of AI into routine USG-guided regional anesthesia practice holds promise for improving procedural consistency and supporting novice practitioners.

Keywords: Artificial intelligence, breast neoplasms, postoperative pain, regional anesthesia.

ÖZ

Amaç: Bu çalışmada, modifiye radikal mastektomi (MRM) uygulanan hastalarda, yapay zeka (AI) entegre ultrasonografi (USG) ile gerçekleştirilen pektoral (PECS II) blokların analjezik etkinliği ve işlem verimliliği, konvansiyonel USG ile karşılaştırıldı.

Hastalar ve Yöntemler: Kasım 2021 - Mart 2023 tarihleri arasında, genel anestezi altında tek taraflı MRM planlanan toplam 70 kadın hasta bu randomize çalışmaya dahil edildi. Hastalar rastgele iki gruba ayrıldı: USG grubu (n = 35) ve AI-USG grubu (n = 35). PECS II blokları, kıdemli bir anesteziyolog gözetiminde dördüncü yıl anesteziyoloji asistanı tarafından uygulandı. Birincil sonlanım noktası, Görsel Analog Ölçeği (VAS) ile değerlendirilen postoperatif 12. saatteki ağrı skoru idi. İkincil sonlanım noktaları; diğer postoperatif zaman noktalarındaki ağrı skorları, toplam opioid tüketimi, ilk 24 saat içinde kurtarma analjezisi gereksinimine kadar geçen süre ve çalışma sonunda asistanın beceri gelişimiydi.

Bulgular: Ortalama yaş 55.3±11.4 (dağılım, 35-75) yıl idi. İntraoperatif remifentanil tüketimi USG grubunda AI-USG grubuna kıyasla daha yüksek olmakla birlikte fark istatistiksel olarak anlamlı değildi ($p > 0.05$). Anestezi ve cerrahi süreleri AI-USG grubunda daha kısaydı (sırasıyla $p = 0.005$ ve $p = 0.008$). İlk 35 hasta ile son 35 hasta arasında lokal anestezik enjeksiyon süreleri karşılaştırıldığında, USG grubunda istatistiksel olarak anlamlı bir azalma saptandı (4.0 dk.'ye kıyasla 3.0 dk., $p = 0.014$). Anestezi sonrası bakım ünitesindeki VAS ağrı skorları başlangıçta AI-USG grubunda daha yüksek bulundu ($p = 0.05$); ancak postoperatif 12. ve 24. saatlerde VAS skorları USG grubuna göre anlamlı derecede daha düşüktü (sırasıyla $p = 0.005$ ve $p < 0.001$). Postoperatif ilk 24 saat boyunca PCA ile sağlanan toplam tramadol tüketimi açısından gruplar arasında anlamlı fark yoktu ($p > 0.05$). Cerrah memnuniyeti skorları AI-USG grubunda daha düşüktü ($p = 0.037$).

Sonuç: Çalışma bulgularımız, AI destekli USG rehberliğinin daha iyi analjezik sonuçlar ile ilişkili olduğunu ve özellikle eğitim sürecindeki asistanlar için klinik ve eğitsel avantajlar sağlayabileceğini göstermektedir. Yapay zekanın rutin USG rehberli rejyonel anestezi uygulamalarına entegrasyonu, işlem standardizasyonunu artırma ve deneyimsiz uygulayıcıları destekleme açısından ümit vericidir.

Anahtar sözcükler: Yapay zeka, meme neoplazmları, postoperatif ağrı, rejyonel anestezi.

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Modified radical mastectomy (MRM) under general anesthesia is one of the most common surgical procedures.[1] Following surgery, almost 40% of women experience acute postoperative pain. Unsuccessful postoperative pain management leading to increased opioid intake causes undesired clinical outcomes. Nearly 50% of these patients experience chronic post-mastectomy pain which can have a detrimental effect on their quality of life throughout their lives.[2]

As part of multimodal analgesia, regional anesthesia techniques are essential for reducing postoperative pain.[3] Thoracic epidural and thoracic paravertebral blocks (TPVBs) are standard methods.[4] Recently, the Procedure-Specific Pain Management (PROSPECT) guideline recommends performing pectoral blocks (PECS block) by ultrasonography (USG) as an alternative to thoracic epidural and paravertebral blocks.[5] Pectoral blocks are recently described blocks widely used in breast surgery to inject local anesthetics into the interfascial plane under USG guidance. Blanco et al.[6] reported that all pain sources in breast cancer were controlled with the PECS II block. However, the results from several randomized-controlled trials evaluating the safety and efficacy of PECS blocks are inconclusive.[7-10] A systematic review demonstrated that there was lower opioid consumption than erector spinae plane block (ESPB) and reduced pain with PECS block compared to control and paravertebral block groups.[11]

Artificial intelligence (AI), integrated into almost every stage of our lives, analyzes complex data in medicine and offers innovative solutions to enhance patient safety. AI-supported monitors and sensors in anesthesiology support clinicians in difficult airway prediction, hypotension, and desaturation cases, and blood loss calculations. It can also reduce hospital stays and costs by predicting postoperative complications.[12-14] Moreover, implementing AI into USG performance during regional anesthetic techniques frequently facilitates learning and provides high-quality analgesia.[15,16] The AI-assisted USG system used in our study incorporates deep learning-based image segmentation, landmark recognition, needle tracking, and AI-enhanced beamforming algorithms. These algorithms work together to improve anatomical visualization, highlight relevant fascial planes, and maintain real-time awareness of the needle tip, even when it is difficult to visualize with conventional USG. Of note, as the innervation of breast tissue is complex and dense, it is challenging for a resident to identify neural structures. This is of utmost importance for educating anesthesiology residents with limited expertise in classical and sonographic anatomy.[16] Besides, AI implementation reduces the complications associated with inadvertent puncture of neural, vascular, and pleural tissues.[17]

In the current study, we aimed to evaluate the analgesic efficacy of PECS block II guided with AI-integrated USG compared to USG-guided PECS block II in patients with breast cancer undergoing unilateral MRM.

PATIENTS AND METHODS

This single-center, prospective, randomized study was conducted at Başkent University Faculty of Medicine, Department of Anesthesiology between November 2021 and March 2023. A total of 70 female patients aged between 18 and 70 years who were in the American Society of Anesthesiologists (ASA) Class I-II and scheduled for MRM surgery were included in this study. Patients with a history of prior breast or other chest surgery on the same side as the planned procedure, bleeding diathesis, local anesthetic allergy, body mass index (BMI) ≥ 40 kg/m^2, injection site infection, chronic pain management, and psychotropic drug use were excluded from the study. The patients were equally randomized into two groups: conventional USG-guided PECS II block group (USG group, n = 35) and AI-assisted USG-guided PECS II block group (AI-USG group, n = 35). A written informed consent was obtained from each patient. The study protocol was approved by the Başkent University Clinical Research Ethics Committee (Date: 16.11.2021, No: KA21/353). The study was conducted in accordance with the principles of the Declaration of Helsinki. The study is registered at ClinicalTrials.gov (NCT06480045).

Standard ASA monitoring was performed in the operating room. General anesthesia induction and endotracheal intubation were performed with propofol, fentanyl, and rocuronium bromide. Anesthesia was maintained with sevoflurane inhalation anesthesia and remifentanil infusion. In the study, a fourth-year anesthesiology resident who completed a standardized training program (10 supervised trials for each block type) in USG-guided upper extremity nerve blocks (axillary, brachial plexus, interscalene), performed PECS II blocks either with or without AI assistance (NerveBlox, Smart Alfa Teknoloji San. ve Tic. A.Ş., Ankara, Türkiye) under the supervision of a senior anesthesiologist.[18] The LOGIQ™ e Pro Edition Ultrasound System was

used (GE Healthcare, IL, USA). NerveBlox is a software-as-a-medical-device designed to assist clinicians in USG-guided peripheral nerve blocks. It uses non-adaptive AI/machine learning (ML) algorithms to provide real-time anatomical labeling, color overlays on key structures, and quality scoring to evaluate image clarity. The platform also aids depth tracking to improve needle guidance, although it does not interact with needle insertion directly. It recognizes anatomical landmarks through color overlays and labels key structures. Besides it offers quality scoring to indicate the adequacy of the USG image and the completeness of the identified anatomy and issues alerts or visual cues, if image quality is suboptimal or key structures are partially obscured.

After general anesthesia, the block was performed under aseptic conditions, using a linear probe in the supine position, with the patient's arm abducted at 90°. A total of 30 mL of 0.25% bupivacaine was injected as a local anesthetic. The patients were randomly allocated to either the USG or AI-USG group using a computer-generated randomization sequence. Allocation was concealed in sequentially numbered, opaque, sealed envelopes prepared by an independent investigator. The envelope was opened immediately prior to the procedure, ensuring unbiased group assignment while maintaining allocation concealment

The patients were, then, prepared for surgery. Vital signs (peripheral oxygen saturation, non-invasive blood pressure, and electrocardiography) were monitored every 5 min throughout the operation, and hemodynamic stability was maintained. At the end of the surgery, the muscle relaxant was antagonized, and the patients were extubated. The patients were transferred to the post-anesthesia care unit (PACU) for further follow-up. Postoperative analgesia was provided with intravenous tramadol delivered by a patient-controlled analgesia (PCA) pump at a predetermined infusion and bolus delivery rate. The patients' pain scores (by Visual Analog Scale [(VAS]), blood pressure, and heart rate (HR) were monitored and recorded at postoperative sixth, 12^{th}, and 24^{th} hours. Postoperative tramadol consumption and additional rescue analgesic requirements were also recorded.

The primary outcome was the postoperative pain score at 12 hours. Secondary outcomes included pain scores at six and 24 hours, time to first rescue analgesia, intraoperative fentanyl requirement, intraoperative HR and mean arterial pressure (MAP), and adverse events such as nausea, vomiting, hematoma, hypotension, and bradycardia.

Statistical analysis

Study power analysis and sample size calculation were performed using the G*Power version 3.1.9.6 (Franz Faul, Universität Kiel, Kiel, Germany). The sample size was based on the primary outcome, the 12-hour postoperative VAS score. Assuming an expected mean difference of 1.0 on the VAS (SD 1.2) between groups, with a power of 90% and a two-sided α of 0.05, a minimum of 32 patients per group was required to detect a clinically meaningful difference in postoperative pain.

Statistical analysis was performed using the IBM SPSS version 25.0 software (IBM Corp., Armonk, NY, USA). The Shapiro-Wilk test was used to determine whether continuous variables were normally distributed, and the Levene test was used to assess the homogeneity of variances. Continuous variables were presented in mean ± standard deviation (SD) or median (min-max), while categorical variables were presented in number and frequency. The significance of differences between groups was assessed using the Student t-test when parametric assumptions were met and the Mann-Whitney U test when they were not. The Pearson chi-square test was used for categorical data analysis, while the Fisher exact probability test or the continuity-corrected chi-square test was used when the observed frequencies were low. The Fisher-Freeman-Halton test was applied in RxC cross-tables. Changes in VAS levels over follow-up time were examined using the Friedman test, and significant results were evaluated using the Dunn-Bonferroni test. A p value of < 0.05 was considered statistically significant.

RESULTS

A total of 70 female patients undergoing MRM were included in the study. The mean age was 55.3±11.4 (range, 35 to 75) years. There were no statistically significant differences between the USG group and AI-USG group in terms of demographic data, including age, BMI, and ASA physical status classification ($p > 0.05$) (Table 1).

Intraoperative remifentanil consumption was higher in USG group than in AI-USG group; however, the difference was not statistically significant ($p > 0.05$). There was no significant difference in hemodynamic parameters intraoperatively ($p > 0.05$).

The durations of anesthesia and surgery were shorter in AI-USG group ($p = 0.005$ and $p = 0.008$,

Table 1. Demographic characteristics of the patients according to groups

	USG group (n = 35)			AI-USG group (n = 35)			
	n	%	Mean±SD	n	%	Mean±SD	*p*
Age (year)			53.2±12.0			57.3±10.5	0.132†
Education level							0.227‡
Primary school or less	7	20.0		6	17.1		
High school	5	14.3		12	34.3		
Vocational school	7	20.0		7	20.0		
University	16	45.7		10	28.6		
Body weight (kg)			67.3±9.4			68.0±7.7	0.729†
Height (m)			1.62±0.034			1.61±0.057	0.335†
Body mass index (kg/m^2)			25.8±3.0			26.5±3.0	0.347†
ASA classification							N/A
I-II	35	100.0		35	100.0		

USG, ultrasonography; AI-USG, artificial-intelligence-assisted ultrasonography; SD, standard deviation; ASA: American Society of Anesthesiologists.

Table 2. Time taken for injection in the first and last series of cases according to USG and AI-USG groups

	First series		Last series		
	Median	Min-Max	Median	Min-Max	*p* ‡¶
Time taken for injection (min)					
USG	4.5	3-16	3	2-8	0.014
AI-USG	5	2-12	4	2-12	0.303
p-value ‡¶	0.525		0.096		

USG, ultrasonography; AI-USG, artificial-intelligence-assisted ultrasonography; ‡, significant in the USG group; ¶, not significant in the AI-USG group

respectively). A comparison of local anesthetic injection times between the first 35 and the last 35 patients revealed a statistically significant decrease in the USG group (4.0 min vs. 3.0 min, $p = 0.014$). In the AI-USG group, injection time also decreased from 5.0 min to 4.0 min; however, the difference was not statistically significant ($p = 0.303$) (Table 2, Figure 1). These findings showed a steeper learning curve in the conventional group, while the AI group started with a more efficient baseline.

The VAS pain scores in the PACU were initially higher in the AI-USG group ($p = 0.05$); however, at 12 and 24 postoperative hours, VAS scores were significantly lower than those in the USG group ($p = 0.005$ and $p < 0.001$, respectively). When VAS changes over time were analyzed using the Friedman test, a statistically significant time effect was observed in both groups ($p < 0.05$). Post-hoc Dunn-Bonferroni analysis demonstrated that VAS scores decreased significantly between PACU and 12 hours, and between PACU and 24 hours within each group ($p < 0.05$ for both comparisons).

Despite these differences, there was no significant difference in total tramadol consumption via PCA during the first 24 hours postoperatively ($p > 0.05$). All patients received identical non-steroidal anti-inflammatory drugs (NSAIDs) for rescue analgesia, with no between-group differences.

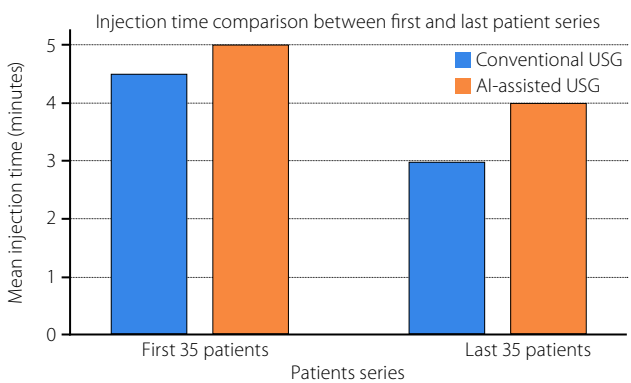

Figure 1. Comparison of injection time in first and second series of patients in the groups and between the groups.
USG, ultrasound; AI-USG, artificial-intelligence-assisted ultrasound.

Bradycardia was less frequent intraoperatively in the AI-USG group, whereas postoperative tachycardia in the PACU was more frequently observed in the USG group (p = 0.014). Surgeon satisfaction scores were lower in the AI-USG group (p = 0.037).

DISCUSSION

In the present study, we evaluated the analgesic efficacy of PECS block II guided with AI-integrated USG compared to USG-guided PECS block II in patients with breast cancer undergoing unilateral MRM. The main finding of this study was that AI-integrated USG could contribute to improved postoperative analgesia at later time points and enhance procedural efficiency, with potential educational benefits for anesthesiology residents. Our findings support previous literature emphasizing the analgesic benefits of PECS II blocks, including reductions in pain scores and improved patient comfort in the early postoperative period.

Recent comparative studies have shown that PECS II is superior to other regional anesthesia techniques. A randomized-controlled study comparing PECS II with TPVB found that PECS II provided longer-lasting analgesia and reduced opioid requirements without increasing adverse effects.[19] Sinha et al.[20] compared USG-guided PECS II block with USG-guided ESPB and demonstrated that PECS II resulted in significantly lower pain scores and morphine consumption in the first 24 hours postoperatively. Consistent with the results reported by Bakeer and Abdallah,[21] we observed a significant decline in VAS scores at 12 and 24 postoperative hours in the AI-assisted PECS II group, indicating prolonged and adequate analgesia. While the analgesic efficacy of PECS II blocks has been demonstrated in previous systematic reviews, their comparison with other techniques, such as paravertebral or ESPB, remains limited.[22] However, another study reported that pain control with the PECS II block lasted only in the immediate postoperative period, compared to the ESPB, in patients undergoing breast-conserving surgery.[23] Factors such as anatomical variability, operator experience, and differences in patient populations may contribute to variability in outcomes. In this context, the standardization and consistency afforded by AI tools may reduce this variability, particularly in training settings. While this study highlights the value of AI for use in education, the lack of objective metrics to assess the learning curve is a significant limitation. Injection time was used as a surrogate marker for procedural efficiency, but future research should incorporate structured assessment tools such as Objective Structured Assessment of Technical Skills (OSATS) or Global Rating Scale (GRS) to more comprehensively evaluate the educational benefits of AI-assisted USG guidance.

Although intraoperative opioid use did not significantly differ between groups, patients in the AI-USG group experienced fewer episodes of intraoperative bradycardia and postoperative tachycardia in the PACU, possibly reflecting more stable analgesic effects and reduced sympathetic response. These physiological indicators, although secondary, may indicate the quality and consistency of block performance when guided by AI-integrated USG.

In our study, VAS scores in the PACU were slightly higher in the AI-USG group but became lower at 12 and 24 hours. This pattern may be related to the onset characteristics of the PECS II block: AI guidance optimizes anatomical identification, but does not directly accelerate initial block onset, which may explain the modestly higher early pain levels. Additionally, systemic analgesic overlap, such as intraoperative fentanyl and PCA-administered tramadol, may influence early PACU pain scores and obscure the immediate effect of the block. However, the lower 12-hour and 24-hour VAS scores in the AI-USG group reflect the sustained analgesic benefit and improved overall block quality provided by AI-integrated USG guidance.

In our cohort, integrating AI into USG guidance notably enhanced anesthesiology residents' performance. The AI-assisted group exhibited a significant reduction in block performance time and improved identification of anatomical landmarks. These findings align with emerging literature suggesting that AI-enhanced imaging can shorten the learning curve for regional anesthesia techniques.[24] A study demonstrated that AI-guided USG enabled non-experts to produce expert-level images after a brief training session, indicating AI's potential to accelerate skill acquisition.[25] Although the reduction in injection time between the first and second series was not statistically significant in the AI group, the resident's initial performance with AI-assisted USG was already superior, with shorter and more consistent procedure times. This suggests that AI may flatten the learning curve by providing immediate structural recognition support, enabling residents to achieve near-expert level efficiency earlier in their training. This is consistent with previous reports, such as those by Cascella et al.[26]

which advocate integrating AI into anesthesiology training to reduce the learning curve and improve anatomical recognition. The role of AI in guiding trainees toward accurate needle placement and fascial plane identification likely contributed to the improved outcomes in our study.

The educational advantage of AI is particularly relevant given the complexity of breast innervation and the challenges inexperienced practitioners face in identifying correct sonographic anatomical landmarks.

A limitation to our study is the lack of formal assessment tools, such as GRS or procedural checklists, to objectively evaluate skill acquisition in residents. Injection time was used as a surrogate marker for procedural efficiency, but future studies should incorporate validated educational metrics to more rigorously assess the impact of AI-assisted USG guidance on resident training.

The AI-enhanced platform used in our study (NerveBlox) provided real-time image recognition and guidance, contributing to a safer and more efficient block procedure. This aligns with emerging literature that positions AI not only as a clinical support tool but also as an active educational adjunct in residency training programs. NerveBlox is an AI support device integrated into a conventional USG. The device's software records and analyzes previously acquired anatomical images from multiple healthy volunteers, identifies and color-codes the blood vessels, nerves, and muscle groups in the USG image, and guides the practitioner in capturing the optimal image for the block. It also provides color guidance for the structure to which the needle will be directed, but it lacks additional features, such as needle-tip marking. The device's software, by recording and analyzing anatomical images from numerous healthy volunteers, identifies and colors the blood vessels, nerves, and muscle groups on the USG image. It guides the practitioner with the ideal image to capture for the block. While NerveBlox enhances visualization, it does not replace the clinician's expertise; rather, it supports anatomical identification before the procedure. Together, these algorithms enhance anatomical visualization, improve identification of deep or subtle fascial planes, reduce operator dependency, and assist with more precise needle guidance. These improvements contribute to greater consistency, efficiency, and safety during USG-guided block procedures.

Another interesting finding of our study was lower surgeon satisfaction observed in the AI-assisted group. This may be explained by several factors. First, limited prior exposure to the AI interface likely introduced a learning curve, which can temporarily reduce workflow familiarity and perceived procedural efficiency. Second, the incorporation of AI overlays and system prompts may have caused minor interruptions or adjustments in the standard workflow, which experienced surgeons may perceive as less streamlined compared to their routine practice. These points suggest that, although AI platforms provide educational and safety benefits, their acceptance among experienced users may depend on increased familiarity and structured training. As AI technologies become more seamlessly integrated into modern handheld USG devices, overall usability is expected to improve, and higher surgeon satisfaction may be observed in future studies.

Another limitation to our study is that all blocks were performed by a single resident under supervision, which restricts external validity. While this approach ensured consistency in technique, it may introduce performance bias and limit the generalizability of our results. Although this study focused on PECS II blocks, the AI-assisted USG platform could potentially be applied to other regional anesthesia procedures. Future studies should include multiple residents with varying levels of experience to more comprehensively evaluate the educational and clinical impact of AI-assisted USG guidance.

Despite its promising outcomes, since all patients received general anesthesia, the objective assessment of block success independent of systemic analgesia remains challenging. Future studies that explore AI-guided blocks should include explicit success metrics, such as a complete sensory block, to further validate these findings. Moreover, long-term outcomes such as the incidence of chronic post-mastectomy pain and its modulation by AI-assisted block techniques remain to be explored.

In conclusion, AI-enhanced USG guidance may offer clinical and educational advantages in the performance of PECS II blocks, particularly for residents in training. In our study, AI assistance was associated with improved analgesic outcomes at later postoperative time points and more efficient block performance. Although additional research using validated competence assessment tools is needed, the integration of AI into routine USG-guided regional anesthesia practice holds promise for improving procedural consistency and supporting novice practitioners.

Author Contributions

E.K.: Idea/concept, control/supervision, literature review, critical review, references and fundings; E.K., Ç.Y.: Design, analysis and/or interpretation, writing the article; Ç.Y.: Data collection and/or processing, materials.

Conflict of Interest

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

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Data Sharing Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

AI Disclosure

The authors declare that artificial intelligence (AI) tools were not used, or were used solely for language editing, and had no role in data analysis, interpretation, or the formulation of conclusions. All scientific content, data interpretation, and conclusions are the sole responsibility of the authors. The authors further confirm that AI tools were not used to generate, fabricate, or 'hallucinate' references, and that all references have been carefully verified for accuracy.

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