Special Article

Optimising artificial intelligence ultrasound tools in anaesthesiology and perioperative medicine: The next frontier for advanced technology application

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ABSTRACT

Artificial intelligence (AI) was once considered avant-garde. However, AI permeates every industry today, impacting work and home lives in many ways. While AI-driven diagnostic and therapeutic applications already exist in medicine, a chasm remains between the potential of AI and its clinical applications. This article reviews the status of AI-powered ultrasound (US) applications in anaesthesiology and perioperative medicine. A literature search was performed for studies examining AI applications in perioperative US. AI applications for echocardiography and regional anaesthesia are the most robust and well-developed. While applications are available for lung imaging and vascular access, AI programs for airway and gastric US imaging solutions have yet to be available. Legal and ethical challenges associated with AI applications need to be addressed and resolved over time. AI applications are beneficial in the context of education and training. While low-resource settings may benefit from AI, the financial burden is a considerable limiting factor.

Keywords: Anaesthesiology, artificial intelligence, machine learning, medication, monitoring, perioperative medicine, point-of-care ultrasound, regional anaesthesia

INTRODUCTION

What exactly is artificial intelligence (AI)? If you ask ChatGPT 3.5, AI is the simulation of human-intelligence processes by computer systems, and the simulation enables the systems to perform tasks that require human intelligence, such as learning, reasoning, problem-solving, perception, and language processing.[1] Professor John McCarthy, credited with coining the term *artificial intelligence*, defined AI in simpler terms in 1955 as 'the science and engineering of making intelligent machines'.[2] Today, AI is any technique that enables computers to mimic human intelligence. Machine learning is a subset of AI and includes techniques that enable machines, through experience, to improve at specific tasks [Figure 1]. Examples of machine learning include credit card fraud detection and automatic friend-tagging suggestions on social media. Machine learning also includes deep learning, which relies on artificial neural networks to reach accurate conclusions without human intervention [Figure 1]. Examples of deep learning applications include programming suggestions by streaming services and language processing by virtual assistants. Details of techniques in AI and specific types of learning are beyond the scope of this review; thus, the authors refer an interested reader to a review by Hashimoto *et al*.[3]

The expansive growth of AI has generated useful tools for optimising operator experience and task

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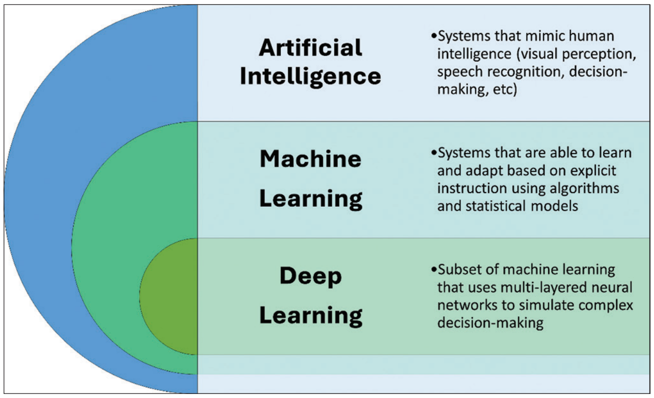

Figure 1: Conceptual relationships of deep and machine learning under the study and development of artificial intelligence

automation. Potential benefits of AI-powered programs in anaesthesiology have been outlined in six major themes: (1) anaesthesia monitoring, (2) medication administration, (3) event and risk prediction, (4) ultrasound (US) guidance, (5) pain management, and (6) operating-room logistics.[3] This review focuses on AI applications in ultrasonography for the clinical anaesthesiologist.

METHODS

We performed a literature search on PubMed using the keywords 'artificial intelligence', 'ultrasound', and 'anest*' over the past five years (January 2020–May 2024), resulting in 305 publications. The number of publications dramatically increased over the past three years—67 in 2021, 78 in 2022, and 79 in 2023. There were already 76 in 2024. Articles unrelated to US or anaesthesiology (e.g. cancer diagnosis) were excluded. All articles were in English. They included articles describing the use of AI in ultrasonography in perioperative anaesthesiology, specifically applications in regional anaesthesia (RA), echocardiogram, lung imaging, and vascular access.

AI-POWERED APPLICATIONS IN ANAESTHESIOLOGY

AI in point-of-care ultrasound (POCUS)

One of the most dazzling applications of AI is the capacity for image and video analyses. One of the first AI-powered applications involved medical imaging. Numerous assistive AI programs have been proposed for imaging in radiology, such as computed tomography–enhanced cancer detection, and some of these programs are already commercially available.[4-6] In addition, significant progress has been made in analysing video imaging in medicine; one example is GI Genius (Medtronic, Minneapolis, MN, USA), the first FDA-approved AI device for flagging irregularities in colonoscopy.[7] Initial studies showed GI Genius to be reasonably helpful—non-inferior to expert endoscopists (clinicians who performed >2000 colonoscopies). Using GI Genius, non-experts showed a 21% improvement in detecting adenomas.[8,9]

In anaesthesiology, we rely heavily on the US as a diagnostic tool. US imaging, also affectionately known as (POCUS), enables real-time imaging for immediate bedside assessment and decision-making. Furthermore, developing handheld US devices has been highly favourable because they are affordable, portable, and accessible in various healthcare settings (e.g. in-patient hospitals, ambulatory surgical centres, and rural and remote settings).[10]

Analysis of US-acquired images with AI has posed a challenge because of the dynamic nature of image acquisition, variability of technique and anatomy, and intrinsic noise. The development of machine learning at the turn of the century and of deep learning in the 2010s has made it possible to develop image procurement and interpretation algorithms to identify objects in the image and interrogate the video clip for functional information, such as lung movement, ejection fraction, valve function, and tracking a needle tip. Major US manufacturers are racing to develop AI algorithms to augment US image acquisition and analysis, and some of these algorithms are already available in a limited capacity.

Features of AI algorithms with the greatest potential to augment US imaging include image optimisation assistance, anatomy identification, estimation of cardiac function, cardiac-valve interrogation, and quantification of fluid volume.

Transthoracic echocardiogram

Although technically challenging, a transthoracic echocardiogram is a great tool for an expedient cardiac examination to estimate cardiac function and characterise valvular disease with limited information. Fortunately, much of the progress in image analysis has been specific to the cardiac examination, with most US manufacturers offering at least some assistive features. One comprehensive AI product that is commercially available is a proprietary algorithm named Kosmos, developed by EchoNous (Redmond, WA, USA). Kosmos uses AI to assist the anaesthesiologist with identifying and interrogating cardiac anatomy, calculating ejection fraction, and assessing ventricular function [Figure 2].[11] Another helpful feature of Kosmos is the immediate feedback during image acquisition regarding probe placement, tilt, and rotation. Feedback on image optimisation helps the user become skilful over time, and the feedback helps in a setting where POCUS experts are not available for consultation.[12] In a single-centre study by Baum *et al.*,[13] a randomised investigation showed that novice users with POCUS devices equipped with AI functionality had a shorter apical 4-chamber acquisition time and higher image-quality scores.

US imaging of the lungs

POCUS facilitates the assessment of critical lung pathologies in the operating room and the intensive care unit. Most novices can appreciate the absence of normal *lung-sliding* motion in the pneumothorax. Hence, some of the most helpful features of AI algorithms in lung US include quantifying B-lines in pleural oedema and quantifying pleural effusions to assist clinical diagnosis and management decisions.[14] A recent prospective study showed a potential supportive role of AI algorithms for lung US for non-expert clinicians in low-resource settings in Vietnam.[15] In this study, clinicians were asked to identify the findings in a series of 10 US video clips for patients hospitalised with dengue fever and septic shock, and the clinician's responses were compared to the expert's assessment. The study found that when supported by the real-time AI-assisted lung US system for interpreting lung-US clips, non-experts improved their accuracy of interpretation of prospective real-time lung US from an average of 68.1% to 93.4% ($P < 0.001$).[15] In the wake of the coronavirus disease 2019 (COVID-19) pandemic, another study found that the AI application of guided B-line quantification was used to detect COVID-19 pneumonia.[16] Kuroda *et al*. found that this AI function correlated well with computed tomography findings of pneumonia, with an accuracy of 94.5% for 12 zones (bilateral anterior, lateral, and posterior chest) and 83.9% for eight zones (bilateral anterior and lateral chest).

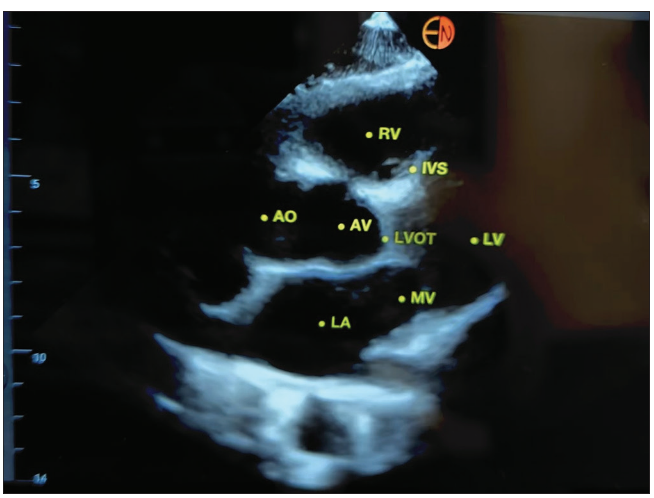

Figure 2: Transthoracic echocardiogram parasternal long-axis image obtained with Kosmos. AI-powered labeling appropriately labels structures- right ventricle, left ventricular outflow track, left ventricle, mitral valve, and left atrium. AO = aorta, AV = aortic valve, IVS = intraventricular septum, LA = left atrium, LV = left ventricle, LVOT = left ventricular outflow track, MV = mitral valve, RV = right ventricle

Airway and gastric US

Emerging trends in using POCUS for the gastric US include evaluating a patient's aspiration risk to mitigate aspiration events, particularly for patients with delayed gastric emptying, patients using glucagon-like peptide-1 receptor agonists, and acutely and critically ill children.[17,18] Mathematical models have been developed to estimate gastric volume, but these do not account for additional risk factors like the particulate nature of gastric contents. An AI-tool solution would greatly benefit perioperative care if it enabled the anaesthesiologist to quantify and characterise these risk factors.[19,20] Pre-anaesthetic airway evaluation using the US is another developing area of POCUS. Literature suggests the distance from skin to epiglottis is currently the most accurate predictor index of a difficult laryngoscopy.[21] However, there is a dearth of literature on using AI for US airway examinations; thus, explorative studies will prove beneficial.

Vascular-access US

In the operating room, the US is commonly used for vascular access. For practised clinicians, using the US for common procedures, such as central venous and arterial access, is second nature. For less-practised clinicians (i.e. those with no US or interventional skills to obtain central femoral venous access, especially during critical haemorrhage), a handheld AI-guided US device has been developed to direct them.[22] This device (1) identifies the femoral vein, (2) directs the user in image optimisation, (3) identifies a safe needle-insertion point, (4) deploys the needle, and (5) prompts the user to advance the guidewire for catheter placement. So far, this device has only been tested on phantoms and porcine models.[22] Yet, continued research and improvement on similar AI-guided technologies could provide support for trainees or novice clinicians in low-resource settings. However, the potential benefits of AI-guided technologies must be compared to the risks for inexperienced operators.

AI in US-guided regional anaesthesia

The field of RA relies heavily on the US to acquire images and guide procedures. Pros of using US in RA include portability, absence of radiation, direct and real-time visualisation of anatomic structures, and local anaesthetic spread.[23,24] However, the success of a block is often operator-dependent, with outcomes affected by factors such as a physician's anatomic knowledge, inattentional blindness, fatigue, technique, and anatomical challenges, such as obesity, trauma, and subcutaneous emphysema.[25] Introducing AI guidance for US imaging with real-time detection of key structures, such as nerves, muscles, fascia, and blood vessels, could significantly improve physician performance. Currently, AI models for these applications include deep convolutional neural networks. For example, the U-Net architecture, developed in 2015 by Olaf Ronneberger at the University of Freiburg in Germany, can segregate and segment grey images.[26] With this technology, machine learning platforms integrated into US systems, such as ScanNav Anatomy Peripheral Nerve Block (Intelligent Ultrasound, Cardiff, UK) and Nerveblox (Pajunk, Geisingen, Germany), have been developed. ScanNav Anatomy Peripheral Nerve Block was approved by the FDA in 2022; it creates colour overlays of key anatomical structures to assist physicians in performing RA [Figure 3]. In a clinical study from April 2021 on ScanNav, experts reviewed the application of the technology and found that the programme identified and recognised key structures with 95%–100% accuracy.[27] Nerveblox, developed in 2020, presents colour-labelled anatomical structures of US images to guide RA procedures.[26,28] Various machine learning models are also being developed to further improve target detection and tracking algorithms.[24]

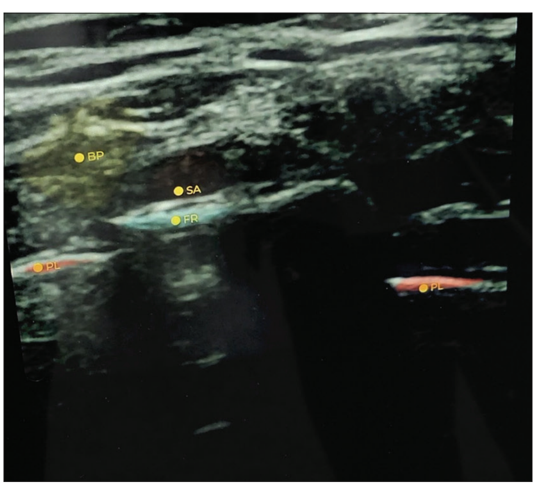

Figure 3: Ultrasound view for supraclavicular block with Nerveblox. Despite a grainy image, the software appropriately labels the brachial plexus, subclavian artery, first rib, and pleural surfaces. BP = brachial plexus, FR = first rib, PL = pleura, SA = subclavian artery

One of the main advantages of AI in US-guided RA is structure identification for non-expert users.[27,29,30] However, more than accurate structure identification is needed to ensure a safe and effective block. Accurate imaging and identifying pertinent structures are merely a foundational component of RA procedures. Safe needle trajectory, needle visualisation, placement, and injection of local anaesthetic into the appropriate location are all crucial components of an operator-dependent, safe, and effective block. NeedleTrainer was built into ScanNav Anatomy US systems to bridge this gap in developing procedural skills. The programme uses retractable needles and augmented-reality technology to simulate procedural conditions in a human patient. This system could be used to improve needling skills in regional nerve blocks as well as vascular access.[26,31]

A study by Bowness *et al*.[30] explored the utility of assistive AI for US scanning in RA, and it showed that both experts and non-experts valued learning and teaching US scanning for RA. Interestingly, non-experts were more likely to give positive feedback on using assistive AI, while experts observing non-experts in a procedure were more likely to report increased risk and safety concerns.[30] Risk and safety concerns are expected with implementing any new technology. By contrast, proceduralists performing RA blocks should be aware of potential risks and understand how to mitigate and address complications. Regrettably, this type of understanding is often relegated to experienced providers and is outside the arsenal of a novice clinician.

CHALLENGES AND LIMITATIONS

Through assistive AI and augmented-reality training, image-optimisation features with instructions for probe placement, tilt, and rotation with repetitive use may be helpful in provider education. However, the traditional learning model under an experienced clinician's supervision is indispensable. Assistive AI is not intended to substitute sound clinical judgment, which cannot be developed without ample exposure to real clinical cases.

As AI-assisted technologies are still in the preliminary stages, detection and tracking errors and image misinterpretation are risks, especially in patients with anatomical variations or abnormal anatomy, such as in trauma. There are also limitations in the technology used for detecting osseous images. Block complications may include block failure, needle trauma, hematoma, nerve injury, pleural injury, peritoneal injury, and local anaesthetic systemic toxicity.[24] In addition to clinical challenges, the legal, financial, and ethical questions associated with implementing AI are still evolving. There are multiple unresolved ethical questions—such as who is responsible for complications when AI is being utilised? In addition, what if AI and clinician assessments are directly opposed? Additional causes of concern are legal responsibility for system errors and the use of faulty data when training these models. The White House of the United States released the 'Blueprint for AI Bill of Rights' as a guide to AI developers and users; however, legal regulation is still limited.[32]

FUTURE DIRECTIONS

A few potential benefits of AI technologies in anaesthesiology include facilitating teaching and learning, quality improvement, reducing the clinician's cognitive workload, improving care recommendations, and providing feedback relating to standard care. However, most AI applications in the US are still in the initial stages of research and development; thus, drawing any conclusions is difficult.[3,33,34] Multiple barriers to clinical application remain, such as uncertainties about the generalisation of algorithms, financial benefits, legal implications, and susceptibility to bias.

Regardless of improvements in AI technology, anaesthesiologists will continue to be essential because of varied clinical cases, AI technological errors, and physician-patient relationships. Because of the wide variability in clinical case type and complexity, anaesthesia-delivery systems should never function autonomously without clinician supervision. Provider-rescue interventions will always be needed if AI makes an unexpected decision or gives a warning during treatment. Technological errors are also inevitable with AI systems; therefore, AI systems need constant clinician supervision.[33] AI systems will not replace anaesthesiologists in the future. Still, these systems have the potential to reduce the cognitive load on physicians so they can focus on pertinent tasks that improve patient care. In the future, AI will integrate into daily clinical practice as a tool for clinicians; therefore, anaesthesiologists must collaborate closely with engineers and scientists in AI systems development.

CONCLUSION

Assistive AI has great potential for successful and widespread implementation in the US in anaesthesiology because of its capacity to aid image acquisition, image optimisation, video interrogation, and feedback. While incorporation into clinical practice has been lagging because of multiple barriers, AI tools in the US will succeed first as educational and personal improvement tools. As AI solutions become increasingly robust, the AI programs for the US have the potential to revolutionise and transform anaesthesiology and perioperative medicine. Still, they will require practising clinicians to collaborate with AI developers to engage actively.

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Conflicts of interest

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REFERENCES

1. ChatGPT (Version 3.5) [Large language model] OpenAI; c2015-2024. Available from: https://chat.openai.com/.
2. Andresen SL. John McCarthy: Father of AI. IEEE Intelligent Systems 2002;17:84-5.
3. Hashimoto DA, Witkowski E, Gao L, Meireles O, Rosman G. Artificial intelligence in anesthesiology: Current techniques, clinical applications, and limitations Anesthesiology 2020;132:379-94.
4. Kiraly AP, Cunningham CA, Najafi R, Nabulsi Z, Yang J, Lau C, *et al*. Assistive AI in lung cancer screening: A retrospective multinational study in the United States and Japan. Radiol Artif Intell 2024:6:e230079. doi: 10.1148/ryai.230079
5. Chassagnon G, De Margerie-Mellon C, Vakalopoulou M, Marini R, Hoang-Thi TN, Revel MP, *et al.* Artificial intelligence in lung cancer: Current applications and perspectives. Jpn J Radiol 2023;41:235-44.

6. Sechopoulos I, Teuwen J, Mann R. Artificial intelligence for breast cancer detection in mammography and digital breast tomosynthesis: State of the art. Semin Cancer Biol 2021;72:214-25.
7. Repici A, Badalamenti M, Maselli R, Correale L, Radaelli F, Rondonotti E, *et al*. Efficacy of real-time computer-aided detection of colorectal neoplasia in a randomized trial. Gastroenterology 2020;159:512-20.e7.
8. Repici A, Spadaccini M, Antonelli G, Correale L, Maselli R, Galtieri PA, *et al*. Artificial intelligence and colonoscopy experience: Lessons from two randomised trials. Gut 2022;71:757-65.
9. Biffi C, Salvagnini P, Dinh NN, Hassan C, Sharma P, Group GIGCS, Cherubini A. A novel AI device for real-time optical characterization of colorectal polyps. NPJ Digit Med 2022;5:84. doi: 10.1038/s41746-022-00633-6
10. Naji A, Chappidi M, Ahmed A, Monga A, Sanders J. Perioperative point-of-care ultrasound use by anesthesiologists. Cureus 2021;13:e15217. doi: 10.7759/cureus.15217
11. Kosmos by EchoNous. EchoNous, Inc; c2015-2024. Avaliable from: https://echonous.com/kosmos-plus/?utm_term=ultrasound%20ai&utm_campaign=&utm_source=adwords&utm_medium=ppc&hsa_acc=3477071792&hsa_cam=20562115886&hsa_grp=161634935400 &hsa_ad=691771426280&hsa_src=g&hsa_tgt=kwd-530725551486&hsa_kw=ultrasound%20ai&hsa_mt=e&hsa_net=adwords&hsa_ver=3&gad_source=1&gclid=Cj0KCQjw8J6wBhDXARIsAPo7QA-XaK4nmUH-PGegl0nqgtpjA2FpfHwMWhPTwYpKf7OuuJa3Ya_4PJYaAjjxEALw_wcB. Last assessed on July 2024.
12. Serrano RA, Smeltz AM. The promise of artificial intelligence-assisted point-of-care ultrasonography in perioperative care. J Cardiothorac Vasc Anesth 2024;38:1244-50.
13. Baum E, Tandel MD, Ren C, Weng Y, Pascucci M, Kugler J, *et al*. Acquisition of cardiac point-of-care ultrasound images with deep learning: A randomized trial for educational outcomes with novices. CHEST Pulmonary 2023;1:100023.
14. Bhoil R, Ahluwalia A, Chopra R, Surya M, Bhoil S. Signs and lines in lung ultrasound. J Ultrason 2021;21:e225-33.
15. Nhat PTH, Van Hao N, Tho PV, Kerdegari H, Pisani L, Thu LNM, *et al*. Clinical benefit of AI-assisted lung ultrasound in a resource-limited intensive care unit. Crit Care 2023;27:257. doi: 10.1186/s13054-023-04548-w
16. Kuroda Y, Kaneko T, Yoshikawa H, Uchiyama S, Nagata Y, Matsushita Y, *et al*. Artificial intelligence-based point-of-care lung ultrasound for screening COVID-19 pneumoniae: Comparison with CT scans. PLoS One 2023;18:e0281127. doi: 10.1371/journal.pone.0281127
17. Baldawi M, Ghaleb N, McKelvey G, Ismaeil YM, Saasouh W. Preoperative ultrasound assessment of gastric content in patients with diabetes: A meta-analysis based on a systematic review of the current literature. J Clin Anesth 2024;93:111365.
18. Valla FV, Tume LN, Jotterand Chaparro C, Arnold P, Alrayashi W, Morice C, *et al*. Gastric point-of-care ultrasound in acutely and critically ill children (POCUS-ped): A scoping review. Front Pediatr 2022;10:921863. doi: 10.1016/j.jclinane.2023.111365
19. Perlas A, Mitsakakis N, Liu L, Cino M, Haldipur N, Davis L, *et al.* Validation of a mathematical model for ultrasound assessment of gastric volume by gastroscopic examination. Anesth Analg 2013;116:357-63.
20. Tacken MCT, van Leest TAJ, van de Putte P, Keijzer C, Perlas A. Ultrasound assessment of gastric volumes of thick fluids: Validating a prediction model. Eur J Anaesthesiol 2021;38:1223-9.
21. Carsetti A, Sorbello M, Adrario E, Donati A, Falcetta S. Airway ultrasound as predictor of difficult direct laryngoscopy: A systematic review and meta-analysis. Anesth Analg 2022;134:740-50.
22. Brattain LJ, Pierce TT, Gjesteby LA, Johnson MR, DeLosa ND, Werblin JS, *et al*. AI-enabled, ultrasound-guided handheld robotic device for femoral vascular access. Biosensors (Basel) 2021;11:522. doi: 10.3390/bios11120522
23. Marhofer P, Greher M, Kapral S. Ultrasound guidance in regional anaesthesia. Br J Anaesth 2005;94:7-17.
24. Viderman D, Dossov M, Seitenov S, Lee MH. Artificial intelligence in ultrasound-guided regional anesthesia: A scoping review. Front Med (Lausanne) 2022;9:994805. doi: 10.3389/fmed. 2022.994805
25. Lloyd J, Morse R, Taylor A, Phillips D, Higham H, Burckett-St Laurent D, *et al*. Artificial intelligence: Innovation to assist in the identification of sono-anatomy for ultrasound-guided regional anaesthesia. Adv Exp Med Biol 2022;1356:117-40.
26. Mika S, Gola W, Gil-Mika M, Wilk M, Misiołek H. Artificial intelligence-supported ultrasonography in anesthesiology: Evaluation of a patient in the operating theatre. J Pers Med 2024;14:310. doi: 10.3390/jpm14030310
27. Bowness J, Varsou O, Turbitt L, Burkett-St Laurent D. Identifying anatomical structures on ultrasound: Assistive artificial intelligence in ultrasound-guided regional anesthesia. Clin Anat 2021;34:802-9.
28. Larkin HD. FDA approves artificial intelligence device for guiding regional anesthesia. JAMA 2022;328:2101. doi: 10.1001/jama.2022.20029
29. Gungor I, Gunaydin B, Oktar SO, M Buyukgebiz B, Bagcaz S, Ozdemir MG, *et al*. A real-time anatomy ıdentification via tool based on artificial ıntelligence for ultrasound-guided peripheral nerve block procedures: An accuracy study. J Anesth 2021;35:591-4.
30. Bowness JS, El-Boghdadly K, Woodworth G, Noble JA, Higham H, Burckett-St Laurent D. Exploring the utility of assistive artificial intelligence for ultrasound scanning in regional anesthesia. Reg Anesth Pain Med 2022;47:375-9.
31. Shevlin SP, Turbitt L, Burckett-St Laurent D, Macfarlane AJ, West S, Bowness JS. Augmented reality in ultrasound-guided regional anaesthesia: An exploratory study on models with potential implications for training. Cureus 2023;15:e42346. doi: 10.7759/cureus.42346
32. Hine E, Floridi L. The blueprint for an AI bill of rights: In search of enaction, at risk of inaction. Minds and Machines 2023;33:285-92.
33. Naaz S, Asghar A. Artificial intelligence, nano-technology and genomic medicine: The future of anaesthesia. J Anaesthesiol Clin Pharmacol 2022;38:11-7.
34. Char DS, Burgart A. Machine-Learning Implementation in Clinical Anesthesia: Opportunities and Challenges. Anesth Analg 2020;130:1709-12.